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WATER QUALITY OF THE SILVER BOW CREEK DRAINAGE; HEAVY METALS AND NUTRIENTS

A PROJECT SPONSORED BY

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WATER QUALITY BUREAU

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ABSTRACT

Between July 21, 1977 and September 18, 1977, a chemical analysis was made on samples taken from 21 sites along the Silver Bow Creek Drainage. On nine different occasions samples were taken and values recorded for stream flow, temperature, pH, specific conductance, cadmium, copper, zinc, Kjeldahl nitrogen, ammonia, nitrate plus nitrite, phosphorous and phosphate.

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I. INTRODUCTION

The water quality of Silver Bow Creek and the Upper Clark Fork River Drainage has been a much debated subject. Before the Anaconda Company made efforts to clean up Silver Bow Creek there was little doubt that the water quality was poor. Since these efforts to clean up the water were begun, many studies have been done to determine the extent of water quality improvement. The Anaconda Company, university researchers and government organizations have all monitored and tested the water in Silver Bow Creek to determine sources of pollution and the extent of pollution.

These studies dealt mainly with ecological, bacteriological or biological aspects of water quality along Silver Bow Creek and the Upper Clark Fork River Drainage. Few published papers were found dealing with the chemical pollution aspects of the water and those that were found were not exhaustive treatments of Silver Bow Creek alone. The Anaconda Company, Butte Operations routinely samples 14 stations along Silver Bow Creek from Butte to Gregson collecting samples for sulfate and heavy metal analyses. These studies are done by the Environmental Engineering Department.

A 3-day preliminary study done by the Montana Water Quality Bureau during the summer of 1976 was used as a guideline for the present research. The sampling sites used in the 1976 study were also used for this study with the addition of sites #15A, #16A and #16B. The parameters analyzed in the 1976 study were duplicated with the addition of pH and specific conductance measurements. Other analyses include determination of total phosphorus, orthophosphate, nitrate plus nitrate, ammonia, Kjeldahl nitrogen, copper, cadmium, zinc, temperature and stream flow.

During the period from July 21, 1977 through September 18, 1977 water samples were collected at 21 sampling stations in the Upper Clark Fork River Drainage. Approximately once a week on nine different occasions, samples were collected and analyzed. Nutrient samples were analyzed by the Montana Department of Health and Environmental Sciences' Water Quality Lab in Helena and metal analyses were done at the Montana College of Mineral Science and Technology in Butte. On runs #1, #4 and #9, metal samples were divided and duplicates sent to the lab in Helena for analysis. A comparison of these values is listed in the Appendix.

Sampling sites are listed in Table #1 along with geographic location and detailed description. Efforts were made, through sampling sequence, to insure as closely as possible that the same body of water was sampled as it moved downstream.

II. METHODS

One liter grab samples were taken on the dates indicated. Nutrient samples were preserved with 4 mg $HgCl_2$. Metal samples were preserved with 5 ml of triple distilled, 90% pure HNO_3. Stream flow, specific conductance and temperature were measured in the field at the time the samples were taken. Samples for pH were taken in the field and measured in the lab within 12 hours.

Copper and zinc were analyzed using an Instrumentation Laboratories 251 atomic absorption flame spectrometer. Cadmium was analyzed using a Perkin-Elmer 403 atomic absorption spectrometer with an HGA 2200 furnace and microsampler. The State of Montana Health and Environmental Sciences' Water Quality Lab checked the metal analyses on runs #1, #4 and #9 by atomic absorption flame analysis using a Varian AA6 spectrometer.

Nutrient samples were analyzed by the state laboratory in Helena. Nitrate plus nitrite analysis was made using the automated hydrazine reduction method. Ammonia was analyzed using the automated phenylate method and Kjeldahl nitrogen was analyzed using manual digestion followed by the automated phenylate method. Analysis of total phosphorus was made using manual persulfate digestion and subsequently followed by the automated ascorbic acid method. Orthophosphate was also analyzed by the automated ascorbic acid method.

Specific conductance was measured using a Lab-Line MC-1 Mark IV Lectro mho meter standardized to 25° C. A corning Model 7 pH meter was used to measure pH. Temperature was taken with a Celsius thermometer and was read to the nearest 0.5^{o} C.

III. DESCRIPTION OF SAMPLING DATES

Sample run #1 was taken on Thursday, July 21, 1977. It was a clear, sunny day. Since the Anaconda Company had been on strike for 21 days, both the concentrator in Butte and the smelter in Anaconda were shut down and it was expected that the strike would have some effect on the water quality. Duplicate samples were sent to the Water Quality Lab for comparative analysis of heavy metals.

Sample run #2 was taken on Wednesday, July 27, 1977. It had rained two days prior to the sampling date although it was sunny at the time of sampling. The Anaconda Company shutdown due to the strike had been going on for 27 days. On this run the holding time for the nutrients was exceeded and the nutrient samples had to be discarded.

Sample run #3 was taken on Tuesday, August 2, 1977. The Anaconda Company had settled their strike the day before and employees returned to work on August 2.

Sample run #4 was taken on Tuesday, August 9, 1977. It had rained two days earlier but was sunny and dry at the time of sampling. Duplicate heavy metal samples were sent to Helena for comparison. The Anaconda Company concentrator and smelter had been in operation for one week.

The fifth run was taken on Monday, August 15, 1977. The weather was clear. The 24-hour profiles of both Anaconda raw sewage ditches were taken on this run. This run marked the first time sampling site #15A, the Anaconda raw sewage ditch #2, and sampling site #16A, the smelter discharge #2, were sampled.

The sixth run was taken on Monday, August 22, 1977. It was raining the entire day. Another sampling site, #16B, the arbiter discharge to the Opportunity Ponds, was added on this run.

Sample run #7 was taken on Monday, August 29, 1977. It had not rained for about one week and was clear on the day of sampling. The 24-hour profile of Butte Metro Sewer was taken on this run.

Sample run #8 was taken on Monday, September 12, 1977. The weather was warm and the sky was clear.

The ninth and final run was taken on Sunday, September 18, 1977. It was raining very hard that day. Duplicate metal samples were sent to the state laboratory in Helena for analysis.

IV. DATA

A. Legal Description

The legal description of each of the sampling sites is included in Table 1. The first three numbers refer to the county. 093 is Silver Bow County and 023 is Deer Lodge County. The following numbers refer to section and tract designations, respectively.

B. Tabular Presentation of Data

TABLE 1 DESCRIPTION OF SAMPLING SITES AND LOCATIONS

Site No.	Location	Description
1	093 3N8W24DB	Blacktail Creek 100 yards above its confluence with Silver Bow Creek west of Montana Street on George Street.
2	093 3N8W24DB	Silver Bow Creek immediately above its confluence with Blacktail Creek.
3	093 3N8W23DA	Butte Metro Sewer discharge to Silver Bow Creek.
4	093 3N8W22AC	Silver Bow Creek one-half mile below Slaughter House at bridge.
6	093 3N9W16CA	Silver Bow Creek one mile below Ramsay.
7	093 3N10W12CD	German Gulch Creek one-fourth mile above its confluence with Silver Bow Creek, before the water is diverted through the irrigation pipe.
8	093 3N10W01BCB	Silver Bow Creek under the bridge on the road to Fairmont Hot Springs.
9	093 3N10W01BB	Gregson Creek above its confluence with Silver Bow Creek, on the road to Fairmont Hot Springs.
10	023 4N10W14ABA	Silver Bow Creek at the Stuart Street bridge east of Opportunity.
11	023 4N10W01CCC	Lime ditch from Opportunity Waste Ponds before discharge to Warm Springs Pond #1. Sampled on East Side of Highway 90.
12	023 5N10W36DBA	Opportunity Waste Pond Ditch #2 before discharge to Warm Springs Pond #1. Sampled on east side of Highway 90.
13	023 599W19DBB	Mill-Willow Creek Bypass immediately above its confluence with Warm Springs Pond #2 discharge (#14).
14	023 5N9W18CDA	Warm Springs Pond #2 discharge above its confluence with Mill-Willow Bypass (#13).
15	023 4N11W01DBC	Anaconda Company discharge and Anaconda Raw Sewage #1, 100 yards downstream after flowing together to the Opportunity Waste Ponds.

TABLE 1 (continued)

Site No.	Location	Description
15A	023 4N10W06AC	Anaconda Raw Sewage Ditch #2 to Opportunity Waste Ponds.
16	023 4N11W01DBC	Anaconda Company overflow from their settling pond south of Highway 10A before its confluence with the water from Station 15.
16A	023 4N10W08BDB	Anaconda Company Smelter discharge #2 by the Widsom turnoff to Opportunity Waste Ponds.
16B	023 4N10W06ABB	Anaconda Company Arbiter discharge to Opportunity Waste Ponds.
17	023 5N11W30CCB	Warm Springs Creek 100 yards below Myer's Dam.
18	023 5N9W18DBB	Warm Springs Creek 100 feet above its confluence with Silver Bow Creek to form the Clark Fork River.
19	023 599W18CAA	Clark Fork River at the lower pH shack.

TABLE 2 STREAM FLOW MEASUREMENTS (CUBIC FEET PER SECOND)

(CFS, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	12.06	13.14	11.64	12.11	10.56	9.68	12.79	10.79	12.16
2	19.47	17.03	18.83	6.05	9.36	3.96	5.97	9.49	15.43
3	10.47	11.93	11.60	15.22	13.15	11.26	9.85	13.68	12.37
4	39.27	48.14	41.41	30.26	29.38	22.41	21.21	34.51	44.48
*									
6	38.91	49.89	53.22	31.18	33.01	25.62	26.71	32.66	48.01
7	13.85	13.17	13.19	12.71	5.53	6.00	5.99	4.52	6.97
8	52.29	57.26	50.58	36.13	37.24	32.68	36.48	40.42	58.01
9	.10	.20	.11	.23	.30	.11	.09	.08	.13
10	53.68	52.19	48.05	35.44	33.31	35.79	33.34	36.81	51.36
11	6.14	7.89	11.36	15.42	8.28	8.90	20.78	15.34	14.26
12	3.32	2.89	1.69	.96	.61	.71	1.39	.99	3.45
13	20.67	26.94	18.25	19.94	16.80	20.11	17.75	19.67	21.07
14	61.40	80.47	42.74	38.30	41.45	37.80	41.63	48.23	81.52
15	6.41	7.60	7.78	15.23	17.30	14.57	14.78	13.62	13.15
15A	NT	NT	NT	NT	.90	1.38	.53	.84	1.12
16	4.61	6.08	8.87	4.51	2.64	6.31	7.33	7.79	NT
16A	NT	NT	NT	NT	13.02	7.57	7.58	10.18	5.91
16B	NT	NT	NT	NT	NT	9.66	11.92	4.39	3.33
17	19.04	57.44	45.19	26.27	29.15	37.40	31.89	25.07	42.21
18	4.33	6.71	.80	1.52	.21	.14	3.12	5.15	8.83
19	78.18	95.87	60.60	59.52	50.56	50.00	44.88	75.12	82.12

*Site #5 was dry.

TABLE 3 TEMPERATURE READINGS

(Degrees Centrigrade, Sampling Sites, Runs and Dates)

Site No. *	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	12.	18.	12.5	18.	10.	9.5	8,5	13.
2	19.5	22.	20.	24.	17.	13.	15.	16.
3	19.	18.	17.	18.5	17.5	16.	16.	16.
4	17.	21.	17.	21.	14.	12.	12.5	16.5
* 6	17.	22.	18.	21.	14.	11.	11.	16.
7	17.	15.5	14.	16.	10.5	10.	7.5	10.
8	20.4	14.	19.5	20.5	13.5	12.	12.	13.5
9	22.	17.5	18.5	19.5	15.	NT	NT	NT
10	13.	18.5	21.	19.5	15.	1.5	17.	12.5
11	22.	19.	19.	18.	17.	13.	15.	13.5
12	26.	19.5	20.5	19.	14.	13.	18.	14.
13	24.	22.	19.	20.5	15.5	16.	19.	15.
14	21.	22.	19.5	20.	17.	14.	18.	11.5
15	20.	17.	17.	17.	19.	19.	19.	17.
15A	NT	NT	NT	16.5	16.	17.	19.	19.5
16	16.	15.	11.	17.	18.	14.	12.	NT
16A	NT	NT	NT	18.	22.	17.	23.	23.5
16B	NT	NT	NT	NT	21.	18.	19.5	20.5
17	14.	11.	12.5	14.	9.5	10.	9.5	7.5
18	22.	24.	19.	NT	16.	14.	15.	11.
19	22.	23.	19.5	22.	17.5	15.	17.	13.

NT - Sample Not Taken

*Site #5 was dry; no temperature readings were taken for Run #1.

TABLE 4 pH READINGS

(pH, Sampling Sites, Runs and Dates)

Site No.	*	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1		8.91	8.40	8.21	7.52	7.66	7.11	7.78
2		11.00	6.05	9.97	6.04	11.59	11.02	12.04
3		7.31	7.36	7.31	7.31	7.51	7.25	7.35
4		9.14	7.49	7.38	7.28	8.09	8.02	10.01
* 6		8.82	7.82	7.33	7.60	7.77	7.81	8.62
7		7.89	8.19	8.11	8.19	8.21	8.14	8.30
8		8.32	8.82	8.20	8.12	8.08	8.22	8.02
9		8.09	8.09	8.03	8.00	NT	NT	NT
10		8.60	8.85	7.81	7.45	8.52	8.98	8.21
11		10.88	11.07	10.61	10.91	10.35	10.07	10.90
12		7.60	7.78	7.50	7.87	7.81	7.70	7.57
13		8.31	8.45	8.05	8.18	8.30	8.25	8.31
14		8.55	8.71	8.58	8.70	8.41	8.77	8.42
15		7.50	7.49	11.60	9.31	9.45	7.05	8.32
15A		NT	NT	7.28	7.48	8.21	9.04	7.94
16		8.13	8.32	8.25	8.25	8.34	8.31	8.29
16A		NT	NT	7.57	12.12	11.78	11.98	13.21
16B		NT	NT	NT	9.39	9.00	8.18	8.43
17		8.09	8.30	8.20	8.13	8.39	8.26	8.36
18		7.99	8.13	NT	8.00	8.16	8.08	8.11
19		8.41	8.38	8.39	8.30	8.37	8.52	8.40

NT - Sample Not Taken

*Site #5 was dry; pH readings were not taken for sample runs #1 and #2.

TABLE 5 SPECIFIC CONDUCTANCE MEASUREMENTS

(Micromhos/Cm, Sampling Sites, Runs and Dates)

Site No. *	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29 *
1	260	270	305	235	245	230
2	2330	2630	2100	2550	2500	2050
3	370	405	330	390	390	470
4	1460	1430	755	950	760	670
* 6	1200	1980	750	790	865	500
7	180	140	200	135	150	110
8	1300	1150	905	820	845	585
9	240	225	260	270	270	NT
10	1280	1180	970	790	860	590
11	1200	985	895	780	1280	720
12	2750	2200	2140	2100	2450	1710
13	780	725	670	790	930	585
14	140	520	990	1060	1225	950
15	310	345	325	1040	910	690
15A	NT	NT	NT	400	410	155
16	190	150	230	215	165	150
16A	NT	NT	NT	285	2750	1850
16B	NT	NT	NT	NT	200	220
17	210	170	230	155	180	130
18	1450	790	1190	NT	1360	1190
19	1050	930	890	970	890	620

NT - Sample Not Taken

*Site #5 was dry; no conductivity measurements were made for Runs #1, 8 and 9 as the meter was unavailable.

TABLE 6 CADMIUM CONCENTRATIONS (Mg/L as Cd)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.0064	.0067	<.0005	<.0005	<.0005	<.0079	<.0005	<.0005	<.0005
2	.0057	.0048	.0010	.0099	.0033	.0132	.0065	.0041	.0037
3	.0048	<.0005	.0024	.0063	<.0005	.0037	.0120	.0085	.0020
4	.0078	.0109	.0094	.0122	.0915	.0126	.0097	.0146	.0063
*									
6	.0108	.0102	.0084	.0081	.0120	.0092	.0070	.0072	.0108
7	<.0005	.0022	<.0005	.0013	<.0005	.0011	<.0005	.0026	<.0005
8	.0169	.0098	.0067	.0078	.0068	.0076	.0037	.0046	.0135
9	.0042	.0041	.0005	.0090	.0008	.0012	NT	NT	NT
10	.0132	.0085	.0043	.0054	.0103	.0071	.0071	.0037	.0152
11	.0027	<.0005	.0005	.0024	.0077	.0014	.0011	.0015	.0034
12	.0044	.0063	.0053	.0022	.0020	.0028	.0017	.0035	.0312
13	.0019	.0059	<.0005	<.0005	<.0005	<.0005	<.0005	.0024	.0040
14	.0077	.0044	.0005	.0006	.0043	.0005	.0014	.0007	.0030
15	.0074	.0112	.0360	.0115	.0300	.1380	.0504	.0410	.0096
15A	NT	NT	NT	NT	.0316	.0336	.0088	.0232	.0047
16	.0041	.0130	.0126	.0005	.0010	.0123	.0105	.0005	NT
16A	NT	NT	NT	NT	.1250	.3400	.0196	.0180	.0760
16B	NT	NT	NT	NT	NT	.0059	.0106	.0011	.0114
17	.0015	<.0005	<.0005	<.0005	.0040	<.0005	.0031	<.0005	<.0005
18	.0017	<.0005	<.0005	.0011	NT	<.0005	.0031	<.0005	<.0005
19	.0027	.0005	<.0005	.0005	.0065	.0008	.0005	<.0005	.0089

NT - Sample Not Taken

*Site #5 was dry.

TABLE 7 CADMIUM STREAM LOADS

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.19	.21	<.01	<.01	.01	.19	.02	<.01	<.01
2	.27	.20	.05	.15	.08	.13	.09	.09	.14
3	.12	<.01	.07	.23	.02	.10	.28	.28	.06
4	.75	1.28	.95	.90	6.57	.69	.50	1.23	.69
*									
6	1.03	1.24	1.09	.62	.97	.58	.46	.57	1.27
7	<.02	.07	.02	.04	<.01	.02	<.01	.03	<.01
8	2.16	1.37	.83	.69	.62	.61	.33	.45	1.92
9	<.01	<.01	<.01	<.01	<.01	<.01	NT	NT	NT
10	1.73	1.08	.50	.47	.84	.62	.58	.33	1.91
11	.04	<.01	.01	.09	.16	.03	.06	.06	.12
12	.04	.04	.02	<.01	<.01	<.01	<.01	<.01	.26
13	.10	.39	<.02	<.02	.02	<.02	<.02	.11	.21
14	1.16	.87	.05	.05	.44	.05	.14	.08	.60
15	.12	.21	.68	.43	.28	4.92	1.82	1.37	.07
15A	NT	NT	NT	NT	.07	.11	.01	.05	.01
16	.05	.20	.27	<.01	<.01	.19	.19	.01	NT
16A	NT	NT	NT	NT	3.98	6.29	.36	.45	1.10
16B	NT	NT	NT	NT	NT	.14	.31	.01	.09
17	.07	<.07	<.05	<.03	.28	<.05	.24	<.03	<.05
18	.02	<.01	<.01	<.01	NT	<.01	.02	<.01	<.01
19	.52	.12	<.07	.07	.80	.10	.05	<.09	1.94

NT - Sample Not Taken

*Site #5 was dry.

TABLE 8 COPPER CONCENTRATIONS (Mg/L as Cu)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	<.01	<.01	.03	.03	<.01	.02	<.01	.01	<.01
2	.26	.21	.18	.81	.40	1.47	.72	.38	.32
3	.06	NT	NT	.29	.03	.03	.12	.25	.06
4	.17	.25	.34	.45	.36	.52	.44	.34	.22
* 6	.77	.44	.43	.39	1.50	.39	.39	.35	.64
7	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.03	<.01
8	1.26	.39	.28	.40	.46	.30	.30	.27	.67
9	<.01	<.01	<.01	.02	<.01	.02	NT	NT	NT
10	2.10	.35	.26	.38	1.37	.39	.29	.25	.87
11	<.01	<.01	<.01	.09	.03	.08	.04	.10	.10
12	.05	.08	.06	.07	.06	.06	.05	.03	.12
13	.01	.02	.01	.02	.01	.02	<.01	.01	.01
14	.03	.03	.06	.01	.02	.03	.03	.02	.06
15	.70	.41	11.1	6.2	22.	20.	190.	260.	93.
15A	NT	NT	NT	NT	.69	.70	1.20	2.76	.72
16	.75	.90	1.23	.10	.10	.10	.06	.11	NT
16A	NT	NT	NT	NT	28.	15.	4.46	.33	190.
16B	NT	NT	NT	NT	NT	.03	.06	.07	.06
17	<.01	<.01	<.01	<.01	.01	.01	<.01	<.01	<.01
18	<.01	<.01	<.01	.02	NT	.13	<.01	<.01	<.01
19	.03	NT	<.01	.01	<.01	.01	.01	.01	.02

*Site # 5 was dry.

TABLE 9 COPPER STREAM LOADS

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	<.30	<.32	.85	.89	<.26	.47	<.31	.26	<.30
2	12.38	8.75	8.29	11.99	9.16	14.27	10.52	8.82	12.08
3	1.54	NT	NT	11.25	.96	.83	2.89	8.37	1.82
4	16.33	29.44	34.44	33.31	25.88	28.51	22.83	28.70	23.94
*									
6	73.30	53.70	55.99	29.75	121.14	24.44	25.48	27.97	75.17
7	<.34	<.32	<.32	<.31	<.14	<.15	<.15	.33	<.17
8	161.19	54.63	34.65	35.36	41.91	23.98	26.77	26.70	95.09
9	<.01	<.01	<.01	.01	<.01	<.01	NT	NT	NT
10	275.79	44.69	30.56	32.95	111.64	34.15	23.65	22.51	109.32
11	<.15	<.19	<.28	3.40	.61	1.74	2.03	3.75	3.49
12	.41	.56	.25	.16	.09	.10	.17	.07	1.01
13	.50	1.32	.45	.98	.41	.98	<.43	.48	.52
14	4.51	5.91	6.27	.95	2.03	2.77	3.06	2.36	11.97
15	10.98	7.62	211.14	230.87	930.56	712.47	6866.	8658.	2990.
15A	NT	NT	NT	NT	1.52	2.36	1.56	5.67	1.97
16	8.25	13.39	26.69	1.10	.64	1.54	1.08	2.10	NT
16A	NT	NT	NT	NT	891.34	277.62	82.71	8.22	2745.
16B	NT	NT	NT	NT	NT	.71	1.75	.75	.49
17	<.46	<1.40	<1.10	<.64	.71	.91	<.78	.61	<1.03
18	<.10	<.16	<.02	.07	NT	.04	<.08	.12	<.22
19	5.74	NT	<1.48	1.46	<1.24	1.22	1.10	1.84	4.36

*Site #5 was dry.

TABLE 10 ZINC CONCENTRATIONS (Mg/L as Zn)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.01	.01	.01	.01	<.01	<.01	.01	.02	.02
2	.59	.53	.31	1.6	.89	3.3	1.7	.82	.48
3	.11	.06	.08	.13	.04	.02	2.3	3.2	.30
4	2.0	2.7	2.0	2.4	2.9	3.7	2.9	1.9	1.3
*									
6	2.5	2.4	1.9	1.7	3.7	2.4	2.0	1.7	1.8
7	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.01	<.01
8	2.9	1.5	1.2	1.1	1.7	2.0	1.6	1.3	1.8
9	.01	<.01	.01	<.01	<.01	.03	NT	NT	NT
10	3.6	1.2	1.0	.95	2.7	1.6	1.3	1.0	2.0
11	<.01	<.01	<.01	.02	.09	.01	<.01	.03	.03
12	.01	.14	.18	.14	.15	.18	.15	.14	1.1
13	.16	.02	.03	.02	.02	.01	.02	.02	.03
14	.01	.02	<.01	.01	.01	.03	.02	<.01	.07
15	.12	.09	.88	.30	2.7	94.	39.	56.	54.
15A	NT	NT	NT	NT	.18	.76	.23	3.0	.20
16	.10	.14	.14	.01	.02	.01	.01	.01	NT
16A	NT	NT	NT	NT	3.3	4.3	.85	1.8	3.4
16B	NT	NT	NT	NT	NT	.01	.09	.07	.05
17	<.01	<.01	<.01	<.01	<.01	<.01	.01	<.01	<.01
18	<.01	<.01	<.01	<.01	NT	.02	<.01	<.01	<.01
19	.02	.02	.01	.02	.01	.02	.03	.03	.04

*Site #5 was dry.

TABLE 11 ZINC STREAM LOADS

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #2 7/27	Run #3 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.29	.32	.28	.29	.26	<.23	.31	.54	.59
2	28.08	22.06	14.72	23.66	20.36	31.95	24.81	19.02	18.10
3	2.81	1.75	2.26	4.83	1.28	.55	55.39	107.03	9.07
4	192.03	317.79	202.49	177.56	208.31	202.73	150.38	106.31	141.37
*									
6	273.83	292.23	247.23	129.63	298.63	150.33	130.61	135.75	211.24
7	<.34	<.32	<.32	<.31	.13	<.14	<.14	.11	<.17
8	370.76	210.00	148.40	97.17	154.78	159.80	142.70	128.47	255.25
9	<.01	<.01	<.01	<.01	<.01	<.01	NT	NT	NT
10	472.49	153.12	117.48	82.31	219.89	140.01	105.97	90.00	251.15
11	<.15	<.19	<.27	.75	1.82	.21	<.50	1.12	1.04
12	.08	.98	.74	.32	.22	.31	.51	.34	9.27
13	8.08	1.31	1.33	.97	.82	.49	.86	.96	1.54
14	1.50	3.93	<1.04	.94	1.01	2.77	2.03	<1.17	13.95
15	1.88	1.67	16.73	11.17	114.20	3348.	1409.	1864.	1736.
15A	NT	NT	NT	NT	.39	2.56	.29	6.16	.54
16	1.12	2.08	3.03	.11	.13	.15	.18	.19	NT
16A	NT	NT	NT	NT	105.05	79.58	15.75	44.80	49.12
16B	NT	NT	NT	NT	NT	.23	2.62	.75	.40
17	<.01	<1.40	<1.10	<.64	<.71	<.91	.78	<.61	<1.03
18	<.01	<.16	<.02	<.04	NT	<.01	<.07	<.12	<.21
19	.02	4.68	1.48	2.91	1.23	2.44	3.29	5.51	8.71

*Site #5 was dry.

TABLE 12 KJELDAHL NITROGEN CONCENTRATIONS (TOTAL as N)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.35	1.6	.25	.38	.26	.25	.05	.32
2	.32	.21	.47	.98	2.0	1.0	2.2	1.4
3	16.	15.	13.	19.	14.	16.	12.	17.
4	3.2	3.6	5.4	7.3	6.0	4.2	4.4	4.6
*								
6	2.5	1.6	4.0	30.	4.8	4.8	4.0	2.4
7	.15	.10	.17	.14	.19	.10	.12	.90
8	1.8	1.5	2.5	2.4	2.5	2.3	2.5	2.1
9	.21	.21	.31	.20	.91	NT	NT	NT
10	1.7	.93	1.4	2.4	1.7	1.8	1.7	2.3
11	.22	.18	.23	.19	.24	.55	.61	.55
12	.74	.61	.70	.78	.84	.81	.75	.64
13	.29	.27	.38	.35	.42	.39	.16	.34
14	.34	.39	.55	.48	.51	.48	.40	.55
15	4.6	8.8	4.0	3.7	5.8	7.0	3.5	15.
15A	NT	NT	NT	13.	62.	59.	26.	19.
16	.36	.44	.36	.28	.31	.23	.28	NT
16A	NT	NT	NT	.38	.55	<.05	.33	1.2
16B	NT	NT	NT	NT	.50	12.	.50	.38
17	.15	.07	.12	.12	.24	.14	<.05	.34
18	.55	.75	.75	NT	.97	.72	.55	.59
19	.29	.34	.44	.42	.51	.45	.35	.40

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 13 KJELDAHL NITROGEN STREAM LOADS (TOTAL as N)

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	10.33	45.56	7.41	9.82	6.16	7.82	1.32	9.52
2	15.24	9.67	6.96	22.44	19.37	14.60	51.07	52.85
3	409.84	425.69	484.06	611.26	385.66	385.57	401.62	514.47
4	307.44	364.72	399.77	524.71	328.96	217.94	371.48	500.57
* 6	237.98	208.32	305.13	2422.	300.86	313.66	319.61	281.89
7	5.08	3.22	5.29	1.89	2.79	1.46	1.33	15.34
8	230.27	185.62	220.98	218.66	199.88	205.27	247.22	298.03
9	.05	.06	.17	.14	.24	NT	NT	NT
10	223.26	109.33	121.39	195.39	148.85	146.82	153.09	289.00
11	3.30	5.00	8.68	3.85	5.23	27.96	22.89	19.18
12	6.01	2.52	1.64	1.16	1.46	2.75	1.82	5.40
13	14.66	12.05	18.54	14.38	20.66	16.93	7.70	17.52
14	51.07	40.78	52.21	48.67	47.16	48.88	47.19	109.69
15	72.14	167.49	149.04	156.60	206.75	253.11	116.62	476.77
15A	NT	NT	NT	28.62	209.32	76.50	53.43	52.06
16	4.06	9.55	3.97	1.80	4.79	4.12	5.33	NT
16A	NT	NT	NT	12.10	10.18	<.93	8.22	17.35
16B	NT	NT	NT	NT	11.81	349.95	5.37	3.09
17	6.99	7.74	7.71	8.56	21.96	10.92	<3.06	35.11
18	5.83	1.47	2.79	NT	.33	5.49	6.93	12.74
19	55.47	50.41	64.07	51.95	62.39	49.41	64.32	87.21

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 14 AMMONIA CONCENTRATIONS (TOTAL as N)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.02	.02	.05	.02	.02	.02	.02	.09
2	.04	.06	.06	.64	1.4	.47	.60	.80
3	12.	15.	10.	16.	12.	12.	12.	7.2
4	2.3	2.7	3.8	5.4	4.0	3.1	3.7	1.7
*								
6	1.6	.75	2.2	.16	2.8	3.1	2.8	1.8
7	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
8	12.	.70	1.4	.92	1.3	1.4	1.6	1.4
9	<.01	<.01	.02	.01	.02	NT	NT	NT
10	.70	.32	.42	.49	.39	.58	.26	1.4
11	.06	.09	.09	.09	.10	.16	.13	.18
12	.37	.42	.35	.37	.40	.44	.42	.33
13	.03	.06	.07	.06	.07	.07	.09	.10
14	.03	.04	.04	.02	.01	.01	.02	.04
15	2.0	3.8	1.4	1.5	1.7	2.4	1.6	5.6
15A	NT	NT	NT	6.2	8.0	12.	13.	11.
16	.21	.29	.14	.15	.11	.14	.18	NT
16A	NT	NT	NT	.21	.12	.04	.12	.71
16B	NT	NT	NT	NT	.34	2.6	.34	.23
17	<.01	<.01	.01	<.01	.02	.01	.01	.18
18	<.01	.03	<.01	NT	.03	.02	.01	.01
19	.02	.05	.02	.01	.02	.02	.11	.04

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 15 AMMONIA STREAM LOADS (TOTAL as N)

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.59	.57	1.48	.52	.47	.63	2.45	2.68
2	1.90	2.76	.88	14.66	13.56	6.86	13.93	30.20
3	307.38	425.69	372.36	514.75	330.57	289.18	401.62	217.89
4	220.97	273.54	281.32	388.14	219.30	160.86	312.39	184.99
*								
6	152.31	97.65	167.82	12.92	175.50	202.57	223.73	211.42
7	<.34	<.32	<.31	<.13	<.15	<.15	<.11	<.17
8	153.51	86.62	123.75	83.82	103.94	124.95	158.22	198.69
9	<.01	<.01	.01	<.01	<.01	NT	NT	NT
10	91.93	37.62	36.42	39.93	34.15	47.31	23.41	175.91
11	.90	2.50	3.39	1.82	2.18	8.13	4.88	6.28
12	3.00	1.74	.82	.55	.70	1.45	1.02	2.78
13	1.52	2.68	3.41	2.47	3.44	3.04	4.33	5.15
14	4.51	4.18	3.78	2.03	.92	1.02	2.36	7.98
15	31.36	72.33	52.16	63.49	60.59	86.78	53.31	180.04
15A	NT	NT	NT	13.65	27.01	15.56	26.72	30.14
16	2.37	6.29	1.54	.97	1.70	2.51	3.43	NT
16A	NT	NT	NT	6.69	2.22	.74	2.99	10.26
16B	NT	NT	NT	NT	8.03	75.82	3.65	1.87
17	<.46	<1.11	.64	<.71	1.83	.78	.61	18.59
18	.11	.06	.04	NT	.01	.15	.13	.22
19	3.82	7.41	2.91	1.23	2.44	2.19	20.22	8.72

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 16 NITRATE CONCENTRATIONS (NO_3 + NO_2 - TOTAL as N)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	2.1	17.0	2.6	1.7	1.9	.21	1.9	1.8
2	.50	.38	.49	1.1	1.9	1.4	1.4	1.8
3	.04	.04	.09	.02	.01	.12	.12	<.01
4	.88	.67	.91	.93	1.3	1.3	1.2	1.3
*								
6	.92	1.0	.86	1.3	1.3	1.4	1.2	1.3
7	.01	.03	.01	.01	.01	.01	.02	<.01
8	1.0	1.3	.91	1.3	1.5	1.8	1.8	1.3
9	.03	<.01	.01	.03	.05	NT	NT	NT
10	1.6	1.5	.29	1.5	1.9	2.1	1.7	5.0
11	.10	.06	.06	.05	.05	.18	.49	.18
12	1.2	.30	.31	.30	.24	.23	.46	.08
13	.05	.05	.27	.04	.05	.07	.09	.17
14	.17	.30	.15	.03	.02	.40	.21	.39
15	.29	.27	.21	.19	.17	.15	.11	.61
15A	NT	NT	NT	.05	.01	.04	.52	.02
16	.11	.11	.10	.06	.06	.07	.07	NT
16A	NT	NT	NT	.06	.12	6.3	.07	.07
16B	NT	NT	NT	NT	.07	1.6	.42	.09
17	.05	.05	.21	.04	.06	.05	.06	.17
18	.27	.55	.17	NT	.11	.57	.34	.39
19	.11	.17	.09	.04	.04	.26	.25	.35

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 17 NITRATE STREAM LOADS, (NO_3 + NO_2 - TOTAL as N)

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	61.96	484.12	77.03	43.92	44.99	6.57	50.16	53.55
2	23.82	17.50	7.25	25.19	18.41	20.45	32.50	67.95
3	1.02	1.13	3.35	.64	.27	2.89	4.01	<.30
4	84.55	67.88	67.37	66.85	71.27	67.46	101.31	141.47
*								
6	87.58	130.20	65.60	104.99	81.48	91.48	95.88	152.69
7	.34	.99	.31	.13	.15	.15	.22	<.17
8	127.93	160.87	80.44	118.44	119.93	160.65	177.99	184.49
9	<.01	<.01	<.01	.02	.01	NT	NT	NT
10	210.12	176.33	25.14	122.24	166.36	171.29	153.09	628.26
11	1.50	1.67	2.26	1.01	1.09	9.15	18.39	6.28
12	9.75	1.24	.73	.45	.42	.78	1.11	.67
13	2.53	2.23	13.17	1.64	2.46	3.04	4.33	8.76
14	25.54	31.37	14.24	3.04	1.85	40.74	24.78	77.78
15	4.55	5.14	7.82	8.04	6.06	5.42	3.66	19.61
15A	NT	NT	NT	.11	.03	.05	1.07	.05
16	1.24	2.39	1.10	.39	.93	1.25	1.33	NT
16A	NT	NT	NT	1.91	2.22	116.83	1.74	1.01
16B	NT	NT	NT	NT	1.65	46.66	4.51	.73
17	2.33	5.53	13.50	2.85	5.49	3.90	3.68	17.55
18	2.75	1.07	.63	NT	.04	4.35	4.28	8.42
19	21.04	25.20	13.10	4.95	4.89	28.55	45.94	76.31

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 18 PHOSPHOROUS CONCENTRATIONS (TOTAL as P)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.10	1.6	.10	.10	.068	.12	.078	.11
2	.015	.038	.075	.002	.24	.026	.090	.034
3	1.7	7.5	1.4	6.6	4.7	3.9	4.5	5.4
4	.68	.74	.70	2.0	1.7	.99	1.5	1.0
*								
6	.66	.30	.59	1.0	1.5	1.5	1.9	.69
7	.044	.062	.076	.041	.51	.050	.050	.048
8	.90	1.5	.31	1.1	.85	.55	.73	.72
9	.085	.080	.14	.071	.19	NT	NT	NT
10	.91	.93	.19	.86	.50	.45	.59	.61
11	.006	.15	.015	.002	.017	.009	.015	.020
12	.011	.018	.013	.001	.011	.004	.011	.010
13	.030	.023	.025	.016	.024	.020	.021	.017
14	.032	.026	.032	.025	.037	.031	.027	.013
15	1.0	1.8	.87	3.0	4.1	9.5	12.	7.2
15A	NT	NT	NT	3.4	6.3	5.4	9.3	7.0
16	.055	.040	.13	.001	.013	.005	.005	NT
16A	NT	NT	NT	.42	1.6	.25	.73	26.
16B	NT	NT	NT	NT	.025	.020	.013	.027
17	.006	.016	.025	.012	.027	.006	.006	.014
18	.009	.036	.020	NT	.056	.006	.004	.004
19	.031	.023	.028	.021	.032	.020	.022	.028

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 19 PHOSPHOROUS STREAM LOADS (TOTALS as P)

(Kg/Day, Sampling Sites and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	2.95	45.56	3.11	2.58	1.61	3.75	2.06	3.27
2	.71	1.75	1.11	.04	2.32	.38	2.09	1.28
3	43.54	212.85	52.13	212.33	129.47	93.98	150.94	163.42
4	66.00	74.97	51.82	143.75	93.20	51.78	134.24	108.82
* 6	62.92	39.06	45.62	80.76	94.02	99.33	151.81	81.04
7	1.49	2.00	2.36	.55	7.48	.73	.55	.81
8	115.13	185.62	28.11	100.22	67.95	49.08	72.78	102.18
9	.02	.02	.08	.05	.05	NT	NT	NT
10	119.51	109.33	17.17	70.08	43.78	36.70	53.13	76.65
11	.09	4.17	.57	.04	.37	.45	.56	.70
12	.09	.07	.03	<.01	.02	.01	.03	.08
13	1.51	1.03	1.22	.66	1.18	.87	1.01	.87
14	4.80	2.72	3.03	2.53	3.42	3.16	3.19	2.59
15	15.68	34.26	32.41	126.97	146.14	343.51	399.86	231.49
15A	NT	NT	NT	7.48	21.27	7.00	19.11	19.18
16	.62	.87	1.41	.01	.20	.09	.09	NT
16A	NT	NT	NT	13.38	29.63	4.64	18.18	375.93
16B	NT	NT	NT	NT	.59	.58	.14	.22
17	.28	1.77	1.60	.86	2.47	.47	.36	1.44
18	.09	.07	.07	NT	.02	.05	.05	.09
19	5.93	3.41	4.07	2.59	3.91	2.20	4.04	6.10

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 20 PHOSPHATE CONCENTRATIONS (PO_4 - P)

(Mg/L, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	.084	.17	.085	.078	.065	.062	.068	.098
2	.003	.002	.005	.002	.001	<.001	<.001	<.001
3	1.5	7.6	1.4	6.6	4.5	3.2	3.0	2.2
4	.61	.68	.70	1.6	1.3	.70	.87	.15
*								
6	.61	.32	.57	.017	.89	.76	.64	.18
7	.040	.044	.050	.041	.039	.037	.040	.041
8	.26	.48	.31	.44	.37	.20	.32	.078
9	.060	.067	.075	.060	.064	NT	NT	NT
10	.11	.28	.19	.12	.20	.14	.16	.051
11	.002	.010	.005	.002	.004	.16	.010	.011
12	.009	.008	.010	.001	.001	<.001	.003	.001
13	.021	.014	.017	.006	.006	.005	.007	.009
14	.008	.007	.008	.004	.003	.003	.004	.005
15	.66	.14	.50	1.8	.020	.80	.64	2.0
15A	NT	NT	NT	1.9	2.0	2.6	3.6	3.0
16	.019	.05	.023	.001	.001	.001	.004	NT
16A	NT	NT	NT	<.001	<.001	<.001	<.001	.076
16B	NT	NT	NT	NT	.002	.001	.010	.003
17	.005	.003	.007	.001	.004	.001	.001	.001
18	.005	.101	.015	NT	.003	<.001	.001	.001
19	.013	.008	.010	.003	.004	.005	.004	.004

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 21 PHOSPHATE STREAM LOADS (PO_4 - P)

(Kg/Day, Sampling Sites, Runs and Dates)

Site No.	Run #1 7/21	Run #3* 8/2	Run #4 8/9	Run #5 8/15	Run #6 8/22	Run #7 8/29	Run #8 9/12	Run #9 9/18
1	2.48	4.84	2.51	2.01	1.53	1.94	1.78	2.91
2	.14	.09	.07	.04	.01	<.01	<.02	<.03
3	38.42	215.69	52.13	212.33	123.96	77.06	130.49	66.56
4	58.60	68.90	51.82	115.00	71.23	36.31	73.43	16.31
* 6	58.06	41.66	44.01	1.37	55.75	49.67	51.12	21.13
7	1.35	1.42	1.55	.55	.57	.54	.44	.69
8	33.26	59.39	27.40	40.08	29.58	17.85	31.63	11.06
9	.02	.02	.04	.04	.01	NT	NT	NT
10	14.44	32.91	16.90	9.77	17.51	11.42	14.40	6.40
11	.03	.27	.19	.04	.09	8.12	.37	.38
12	.07	.03	.02	.01	<.01	<.01	<.01	<.01
13	1.06	.62	.83	.24	.29	.22	.37	.46
14	1.20	.73	.76	.40	.27	.31	.47	.99
15	10.35	2.66	18.70	76.13	.71	28.90	21.32	15.40
15A	NT	NT	NT	4.18	6.74	3.36	7.39	8.12
16	.21	1.08	.25	.01	.02	.02	.08	NT
16A	NT	NT	NT	<.03	<.02	<.02	<.02	1.09
16B	NT	NT	NT	NT	.05	.03	.10	.02
17	.23	.33	.45	.07	.37	.08	.06	.10
18	.05	.02	.05	NT	<.01	<.01	.01	.02
19	2.49	1.18	1.46	.37	.49	.55	.73	.87

NT - Sample Not Taken
*Run #2 was discarded as the holding time was exceeded; Site #5 was dry.

TABLE 22 METRO SEWER - 24 HOUR COMPOSITE SAMPLE

(Station #3, August 29-30, 1977)

Time Sampled	0850	1230	1610	2030	0030	0420	0820
Conductivity	470.	450.	285.	445.	395.	480.	430.
pH Readings	7.51	7.42	7.41	7.39	7.31	7.30	7.29
Stream Flow (CFS)	9.85	16.03	13.61	11.75	10.52	5.41	10.83
Temperature (Degrees C)	16.	16.	18.	17.	17.	18.	18.
Total Phosphorous (Mg/L)	3.9	2.5	6.7	9.1	9.5	7.2	5.5
Orthophosphate (Mg/L)	3.2	1.8	5.4	7.9	8.4	6.4	5.0
Kjeldahl Nitrogen (Mg/L)	16.	17.	22.	20.	20.	17.	15.
Total Ammonia (Mg/L)	12.	13.	15.	14.	12.	12.	11.
Total Nitrate (Mg/L)	.12	.04	.02	.02	.02	.02	.01
Zinc-Total Rec.* (Mg/L)	2.18	.11	.15	.12	.10	.05	.07
Copper-Total Rec. (Mg/L)	.12	.08	.11	.07	.06	.05	.05
Cadmium-Tot. Rec. (Mg/L)	.01	<.01	.01	<.01	<.01	<.01	<.01
Total Phosphorous (Kg/Day)	93.98	98.04	223.09	261.59	244.50	95.27	145.72

*Total Recoverable

TABLE 22 (continued)

Time Sampled	0850	1230	1610	2030	0030	0420	0820
Orthophosphate (Kg/Day)	77.11	70.59	179.80	227.09	216.19	84.70	132.48
Kjeldahl Nitrogen (Kg/Day)	385.57	666.69	732.53	574.93	514.75	225.00	397.44
Total Ammonia (Kg/Day)	289.18	509.83	499.45	402.45	308.84	158.83	291.45
Total Nitrate (Kg/Day)	2.89	1.56	.66	.57	.51	.26	.26
Zinc-Tot. Rec. (Kg/Day)	52.53	4.31	4.99	3.45	2.57	.66	1.85
Copper-Tot. Rec. (Kg/Day)	2.89	3.13	3.66	2.01	1.54	.66	1.32
Cadmium-Tot. Rec. (Kg/Day)	.28	.02	.37	.01	.01	<.01	.01

TABLE 23 ANACONDA SEWAGE AND SMELTER DISCHARGE - 24 HOUR COMPOSITE

(Station #15, August 14 - 15, 1977)

Time Sampled	2000	0130	0615	1135	1545
Conductivity (umhos/cm)	1040.	1600.	1030.	1300.	1750.
pH Readings	5.82	11.26	6.03	6.10	11.30
Stream Flows (CFS)	11.24	16.98	17.71	16.91	17.21
Temperature (Degrees C)	20.5	19.0	18.5	18.0	19.0
Total Phosphorous (Mg/L)	3.0	1.2	4.0	3.0	5.4
Orthophosphate (Mg/L)	1.8	.01	.96	.40	.01
Kjeldahl Nitrogen (Mg/L)	3.7	3.7	2.2	4.7	4.1
Total Ammonia (Mg/L)	1.5	1.1	.88	1.8	1.3
Total Nitrate (Mg/L)	.19	.25	.27	.19	.19
Zinc - Tot. Rec.* (Mg/L)	2.7	24.	23.	26.	8.8
Copper - Tot. Rec. (Mg/L)	22.	42.	105.	38.	43.
Cadmium - Tot. Rec. (Mg/L)	.04	.02	.05	.04	.01
Total Phosphorous (Kg/Day)	82.49	49.85	173.31	124.11	227.36
Orthophosphate (Kg/Day)	49.50	.58	41.59	16.55	.42
Kjeldahl Nitrogen (Kg/Day)	101.74	153.70	95.32	194.44	172.63
Total Ammonia (Kg/Day)	41.25	45.69	38.12	74.47	54.74
Total Nitrate (Kg/Day)	5.22	10.38	11.69	7.86	8.00
Zinc - Tot. Rec. (Kg/Day)	74.29	996.38	995.92	1074.96	370.29
Copper - Tot. Rec. (Kg/Day)	604.59	1743.67	4546.59	1571.10	1809.37
Cadmium - Tot. Rec. (Kg/Day)	1.20	.83	2.38	1.52	.56

*Total Recoverable

TABLE 24 ANACONDA SEWAGE DITCH NUMBER TWO - 24 HOUR COMPOSITE

(Station #15A, August 14 - 15, 1977)

Time Sampled	1900	0130	0630	1130	1530
Conductivity (umhos/cm)	400.	470.	380.	500.	450.
pH Readings	7.28	7.29	8.18	7.43	7.29
Stream Flow (CFS)	.90	.85	.40	.95	.60
Temperature (Degrees C)	16.5	14.5	14.0	22.0	20.0
Total Phosphorous (Mg/L)	3.4	3.8	1.0	9.3	6.5
Orthophosphate (Mg/L)	1.9	2.1	.62	4.6	4.6
Kjeldahl Nitrogen (Mg/L)	13.	16.	4.9	25.	16.
Total Ammonia (Mg/L)	6.2	9.4	2.3	14.	7.9
Total Nitrate (Mg/L)	.05	.04	.29	.05	.09
Zinc - Tot. Rec. (Mg/L)	.18	.07	.03	.30	.23
Copper - Tot. Rec. (Mg/L)	.69	.58	.39	1.8	2.0
Cadmiun - To. Rec. (Mg/L)	.07	.02	>.01	>.01	.02
Total Phosphorous (Kg/Day)	7.48	7.90	.99	21.65	9.54
Orthophosphate (Kg/Day)	4.18	4.36	.60	10.69	6.75
Kjeldahl Nitrogen (Kg/Day)	28.62	33.27	4.79	58.10	23.48
Total Ammonia (Kg/Day)	13.65	19.55	2.25	32.54	11.59
Total Nitrate (Kg/Day)	.11	.08	.28	.12	.13
Zinc - Tot. Rec. (Kg/Day)	.39	.14	.03	.69	.34
Copper - Tot. Rec. (Kg/Day)	1.52	1.20	.38	4.37	2.93
Cadmium - Tot. Rec. (Kg/Day)	.03	>.01	>.01	.04	.01

V. CONCLUSIONS

A. HEAVY METALS

The major sources of metal pollution were the Anaconda Company Smelter discharges. There were especially high concentrations of zinc and copper being discharged to the Opportunity Ponds. The table below shows the values.

TABLE 25 HEAVY METAL POLLUTION FROM SMELTER DISCHARGES

(Ranges and Averages in Kg/Day)

Heavy Metal	Site No.	Range	Average
Zinc	15	1.67 - 3348.	995.
	16A	15.75 - 105.	59.
Copper	15	7.62 - 8658.	2290.
	16A	8.22 - 2745.	800.
Cadmium	15	0.07 - 4.92	1.10
	16A	0.36 - 6.29	2.44

The first three sample runs were taken during a strike by the Anaconda Company and before full operations were resumed. The strike ended on August 2, 1977 and operations started shortly thereafter. A comparison of values before and after the strike is seen on the following page in Table 26.

TABLE 26 HEAVY METAL COMPARISONS OF SMELTER DISCHARGE #15

(Before and After Resuming Operations, Kg/Day)

Heavy Metal	Averages of Runs 1, 2, 3 Before August 2, 1977	Averages of Runs 4-9 After August 2, 1977
Zinc	6.76	1414
Copper	76.58	3397
Cadmium	0.34	1.48

The Colorado Tailings immediately southwest of Metro Sewer appears to be a source of heavy metals leaching into Silver Bow Creek. Stream loads above and below the tailings reveal that large amounts of zinc, moderate amounts of copper and small amounts of cadmium are entering the creek at the point of the old tailings. By adding site numbers 1, 2 and 3, a stream load can be calculated immediately above the tailings and site number 4 gives values below the tailings.

TABLE 27 COMPARISON OF HEAVY METALS BEFORE AND AFTER THE COLORADO TAILINGS

(Kg/Day)

Heavy Metals	Average Before Tailings, Sum of Sites 1, 2, & 3	Average After Tailings Site No. 4	Average Increase
Zinc	43.43	188.77	145.34
Copper	15.67	27.04	11.37
Cadmium	0.34	1.51	1.17

B. NUTRIENTS

The major sources of nutrient pollution are from Butte Metro Sewer and the City of Anaconda raw sewage ditches. The table

below shows the values for sites number 3 and 15. Site 15A, the second Anaconda raw sewage ditch, had high concentrations, but stream flow was so low that it was not a major contributor.

TABLE 28 RANGES AND AVERAGES OF NUTRIENT VALUES FOR SITES 3 AND 15

Kg/Day

Nutrient	Site No.	Range	Average
Kjeldahl Nitrogen	3	385 - 611	452
	15	72 - 476	200
Nitrate Plus Nitrite	3	0.27 - 4.01	1.70
	15	3.66 - 19.61	7.54
Ammonia	3	217 - 514	357
	15	31 - 180	75
Total Phosphorous	3	43 - 212	132
	15	15 - 399	166
Ortho-phosphate	3	38 - 216	115
	15	0.71 - 29	22

The Opportunity and Warm Springs settling ponds provide an excellent method of removal for both heavy metals and nutrients.

The Opportunity ponds were more efficient than the Warm Springs ponds in removing all nutrients and metals except orthophosphate and nitrate - plus - nitrite, which were removed equally well by both pond systems.

TABLE 29 SETTLING POND PERCENTAGE REMOVAL

Analysis	% Removed by Opportunity Pond	% Removed by Warm Springs Ponds
Cadmium	92.2	69.0
Copper	99.9	91.3
Zinc	99.7	98.2
Kjeldahl Nitrogen	94.8	78.0
Ammonia	95.7	94.3
Nitrate plus Nitrite	83.4	83.5
Total Phosphorous	99.9	93.4
Orthophosphate	94.1	95.0

It should be pointed out that the retention time of the settling ponds is close to one year and that in order for these figures to be correct it has to be assumed that the concentration of the pollutants going into the ponds has not changed drastically over the past year.

Overall, the settling of efficiency of the ponds is excellent and the final effluent at site #14 is very high quality.

In conclusion, the major sources of metal pollution are the smelter discharges and the major nutrient sources are the Butte Metro Sewer discharge and the Anaconda raw sewage ditches, all of which are effectively removed by the Opportunity and Warm Springs settling ponds before being discharged to form the Clark Fork River.

VI. ACKNOWLEDGEMENTS

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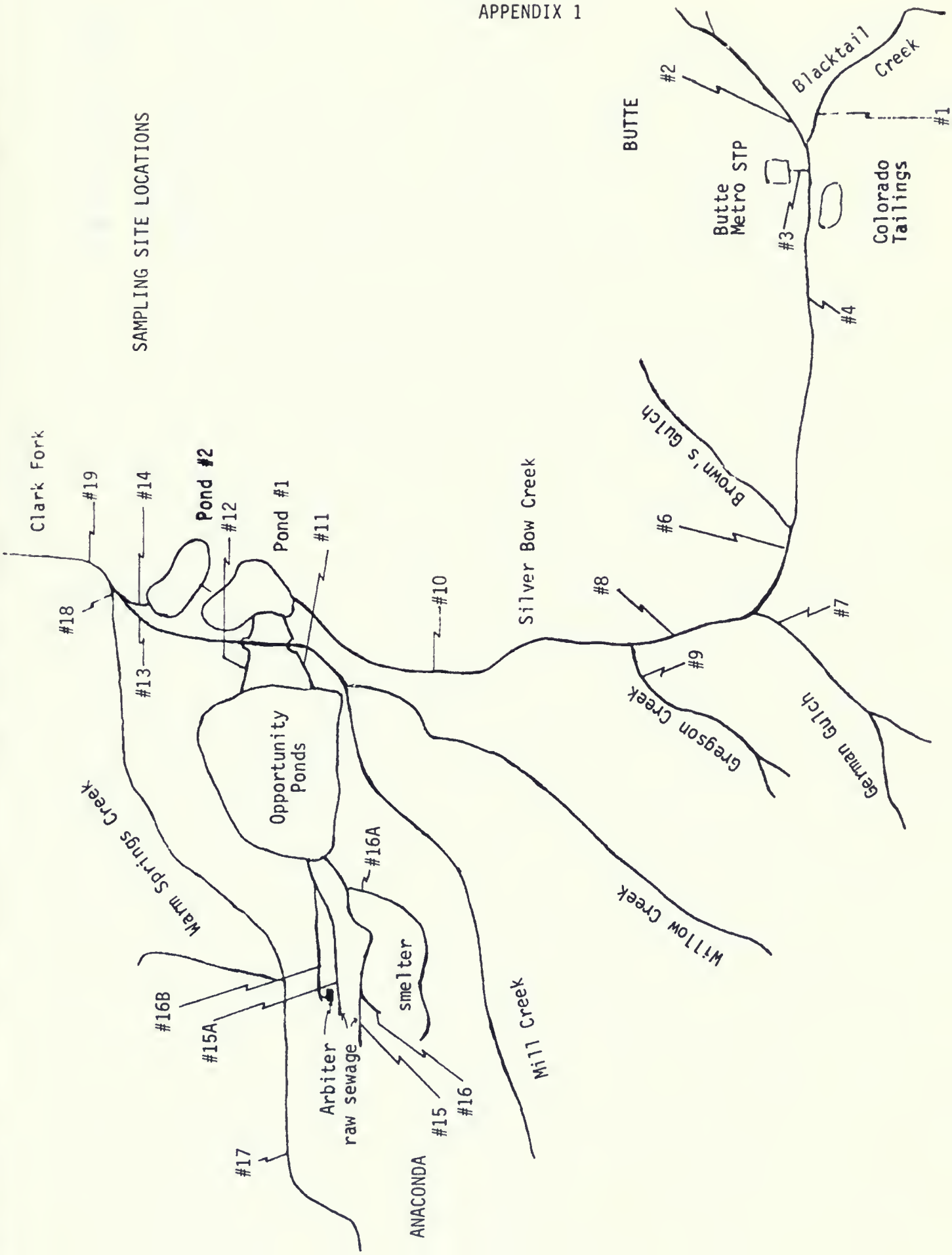
VIII. APPENDIX

Appendix 1 shows the geographic location of each of the sampling sites. This can be correlated with the legal description and location of each which is presented in TABLE 1 on page 5.

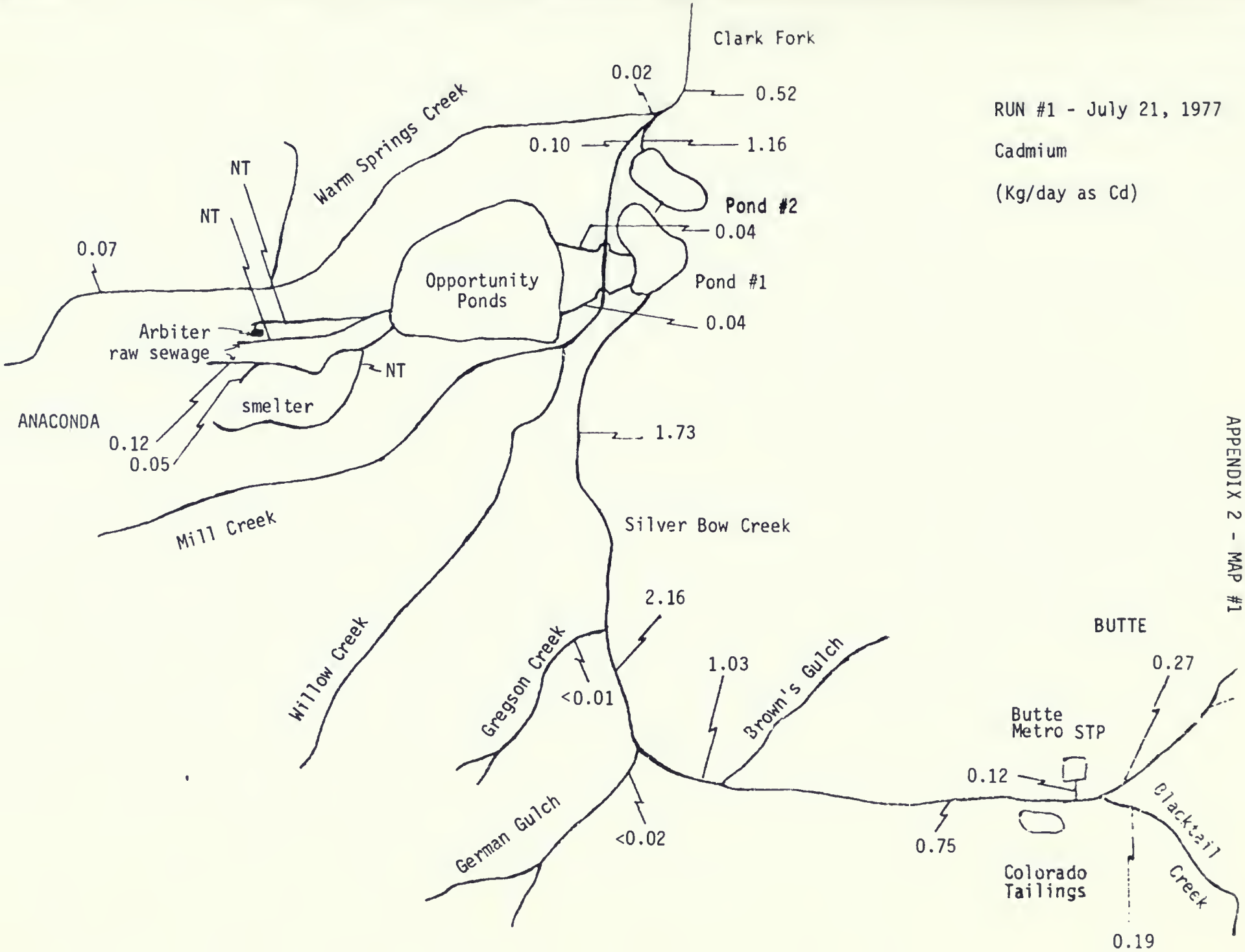
Appendix 2 through 9 shows the map of each of the heavy metal and nutrient values for the nine different sampling runs.

Appendix 10 through 12 list a comparison of the three heavy metals which were analyzed at both the Water Quality Lab in Helena and Montana Tech in Butte.

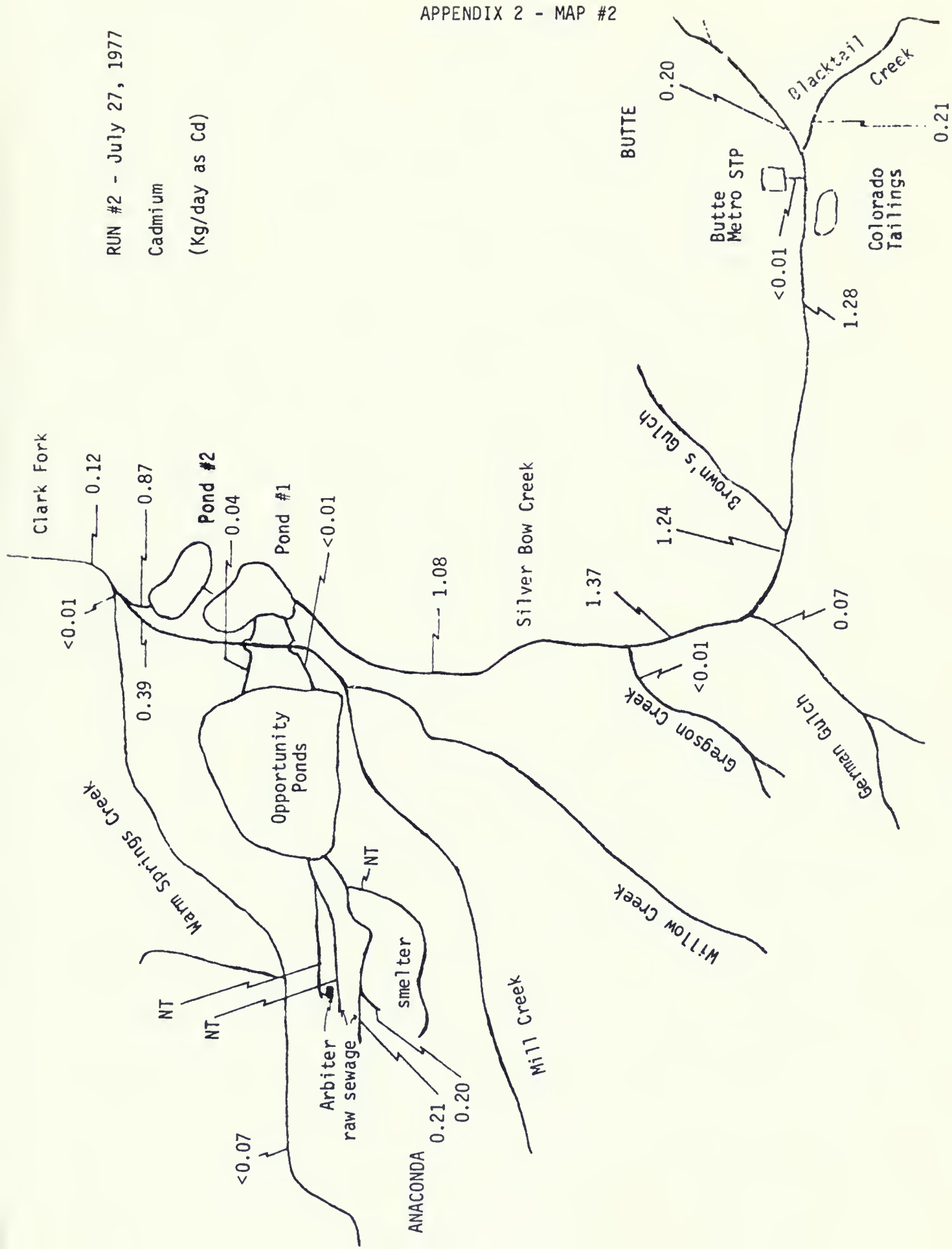
APPENDIX 1


SAMPLING SITE LOCATIONS
Clark Fork
#19
#14
Pond #2
#12
Pond #1
#11
#18
#13
Opportunity Ponds
#10
Silver Bow Creek
#8
#6
Brown's Gulch
BUTTE
#2
Blacktail Creek
#1
Butte Metro STP
#3
Colorado Tailings
#4
#7
#9
Gregson Creek
German Gulch
Willow Creek
Warm Springs Creek
#16A
smelter
#16B
#15A
Arbiter raw sewage
#15
#16
Mill Creek
#17
ANACONDA

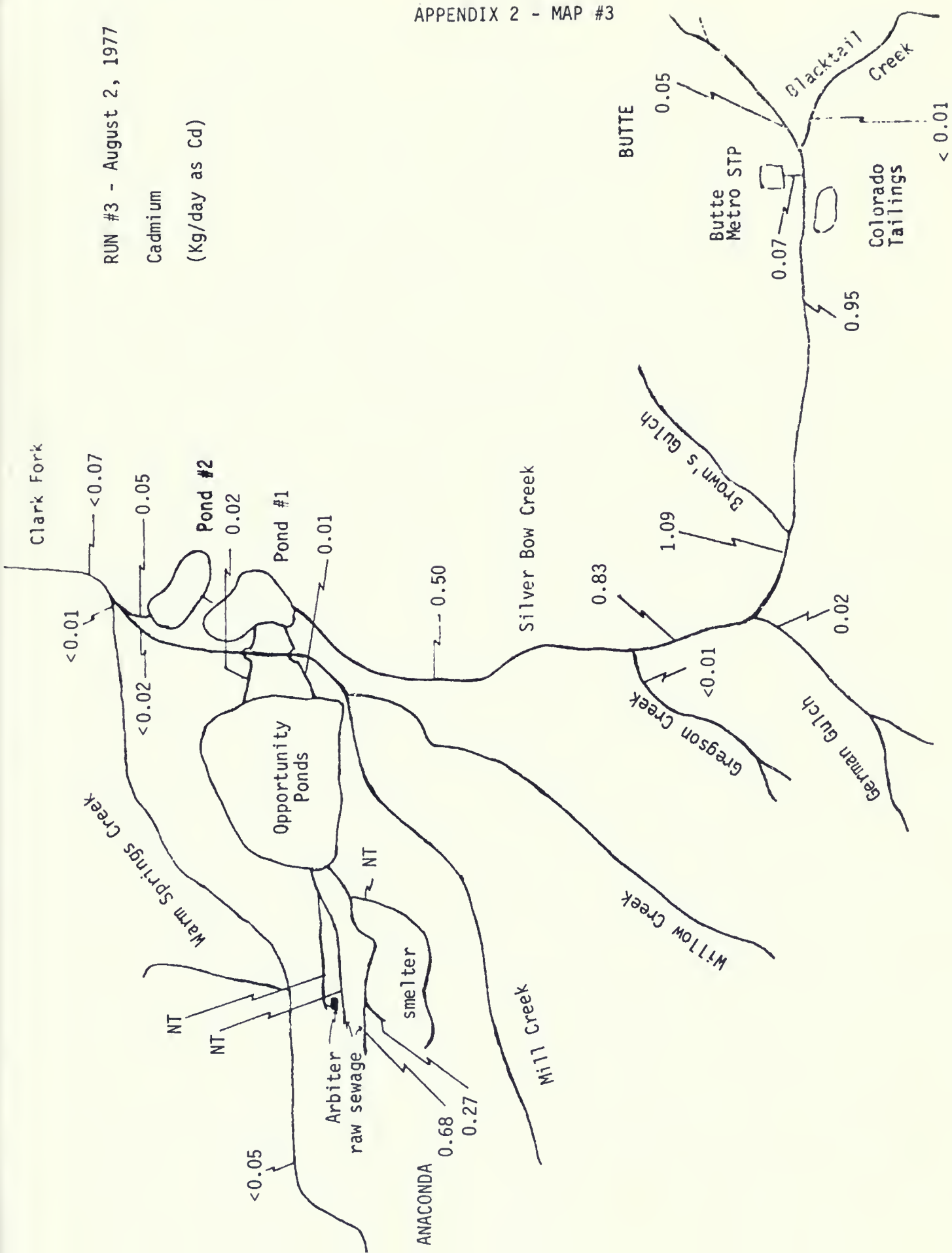
APPENDIX 2 - MAP #1



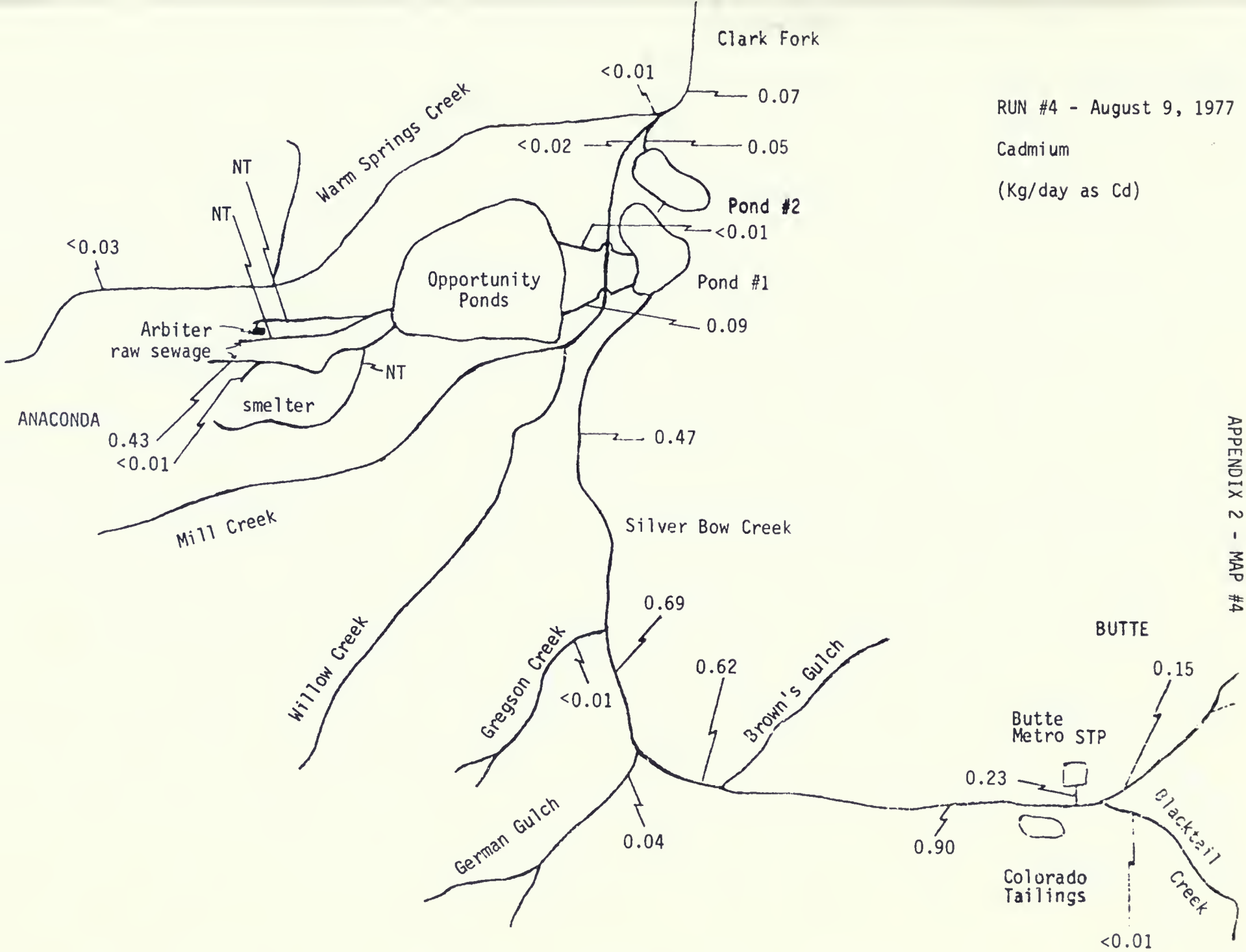
APPENDIX 2 - MAP #2



APPENDIX 2 - MAP #3



APPENDIX 2 - MAP #4

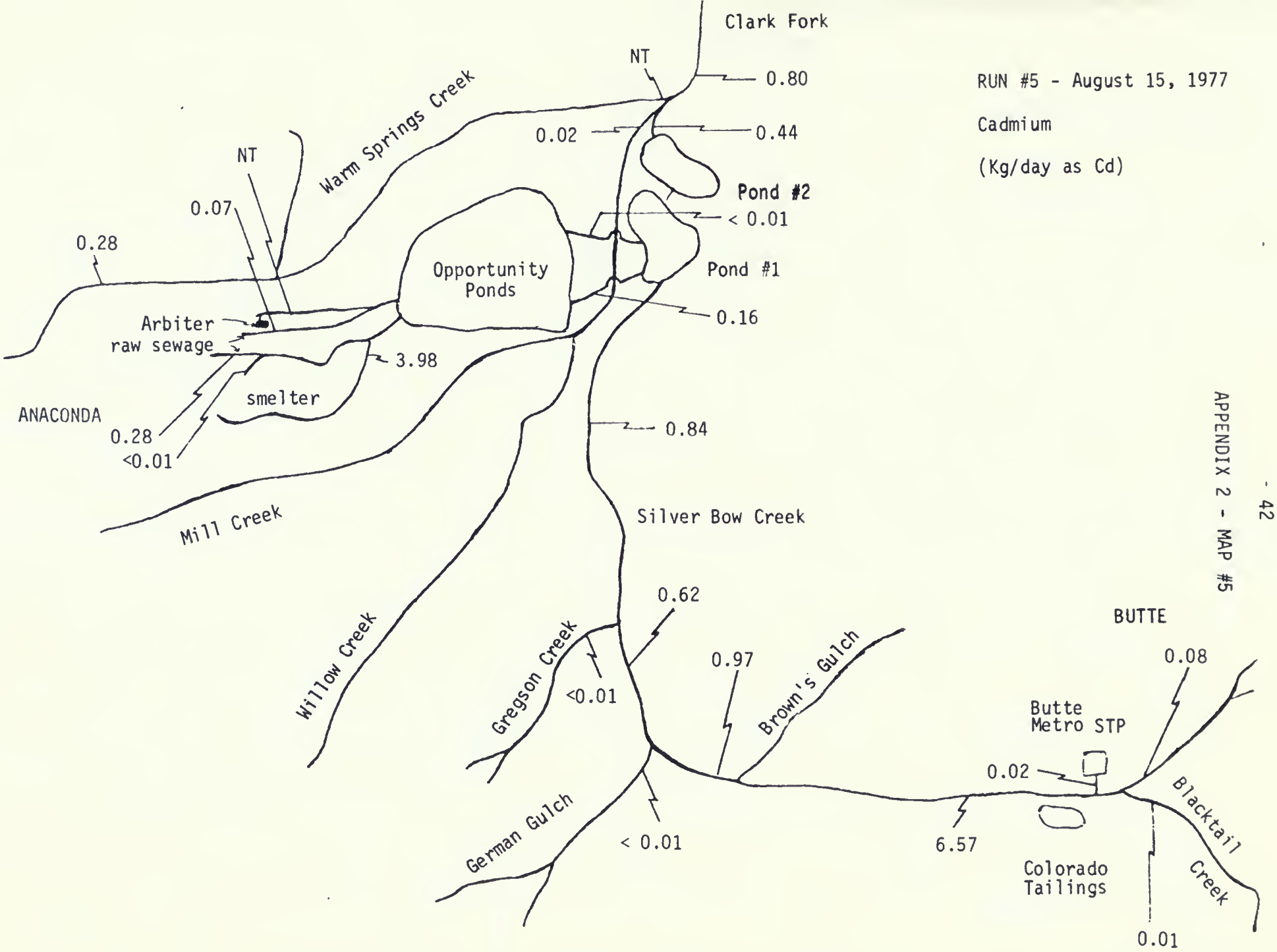


APPENDIX 2 - MAP #5

RUN #5 - August 15, 1977

Cadmium

(Kg/day as Cd)

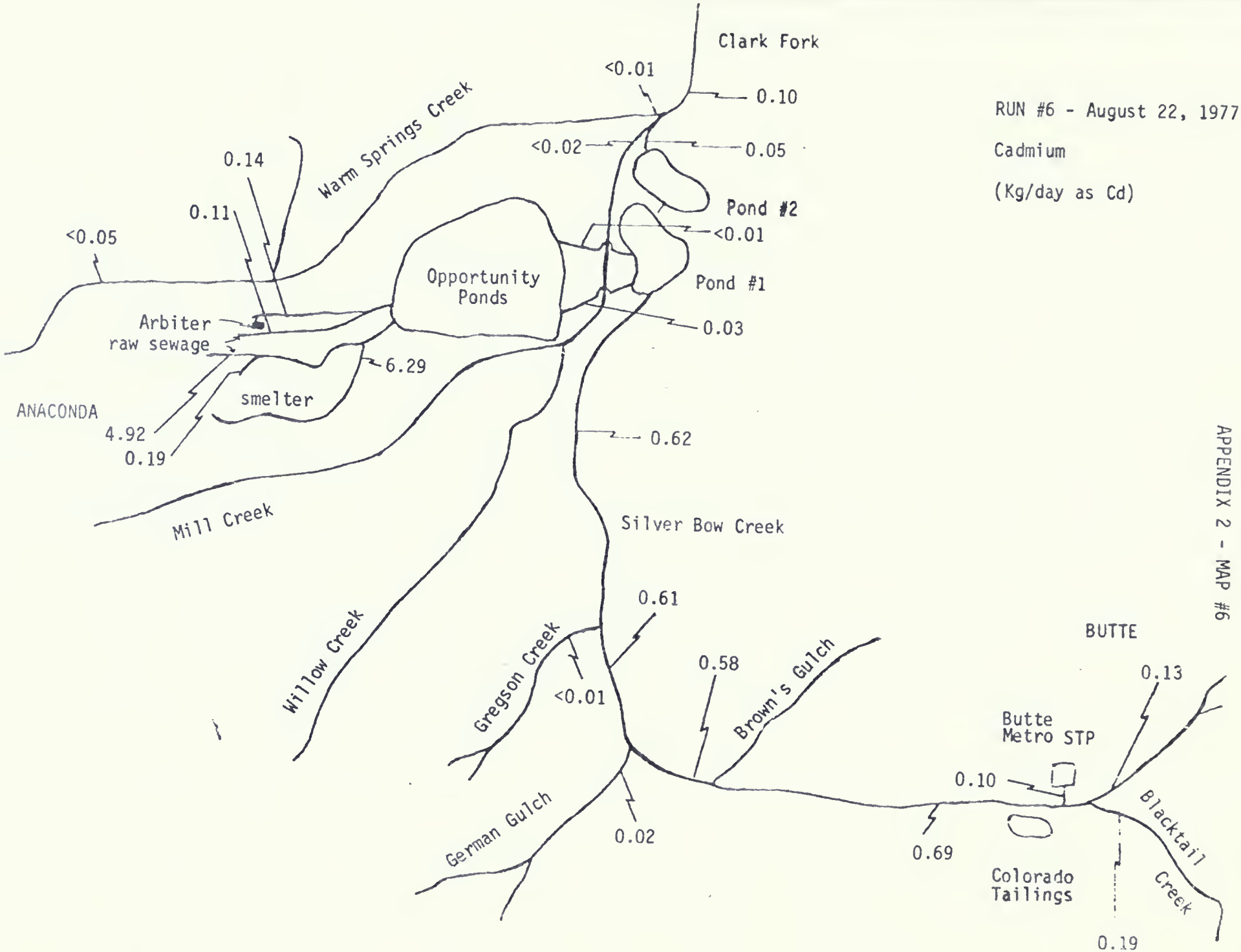


APPENDIX 2 - MAP #6

RUN #6 - August 22, 1977

Cadmium

(Kg/day as Cd)

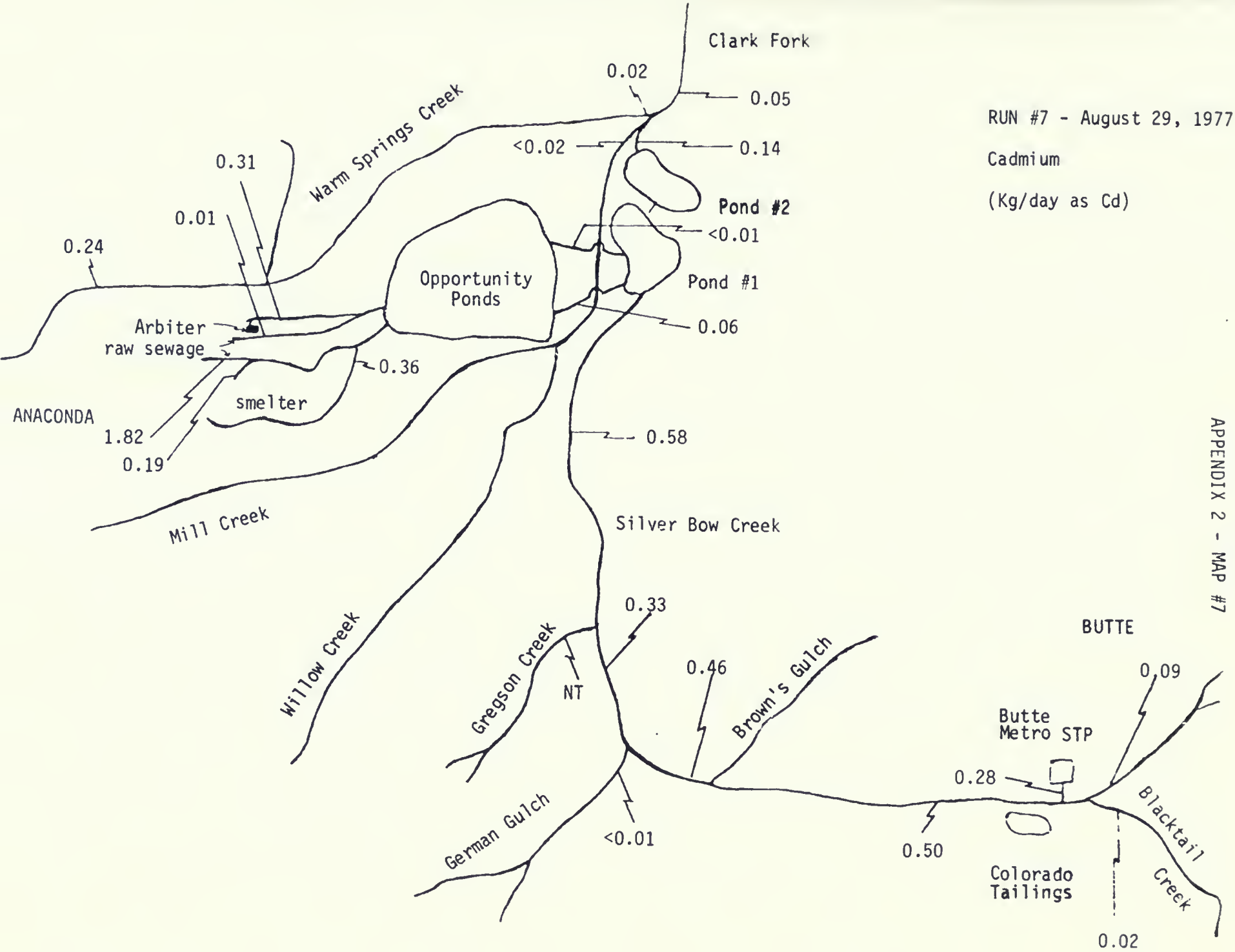


APPENDIX 2 - MAP #7

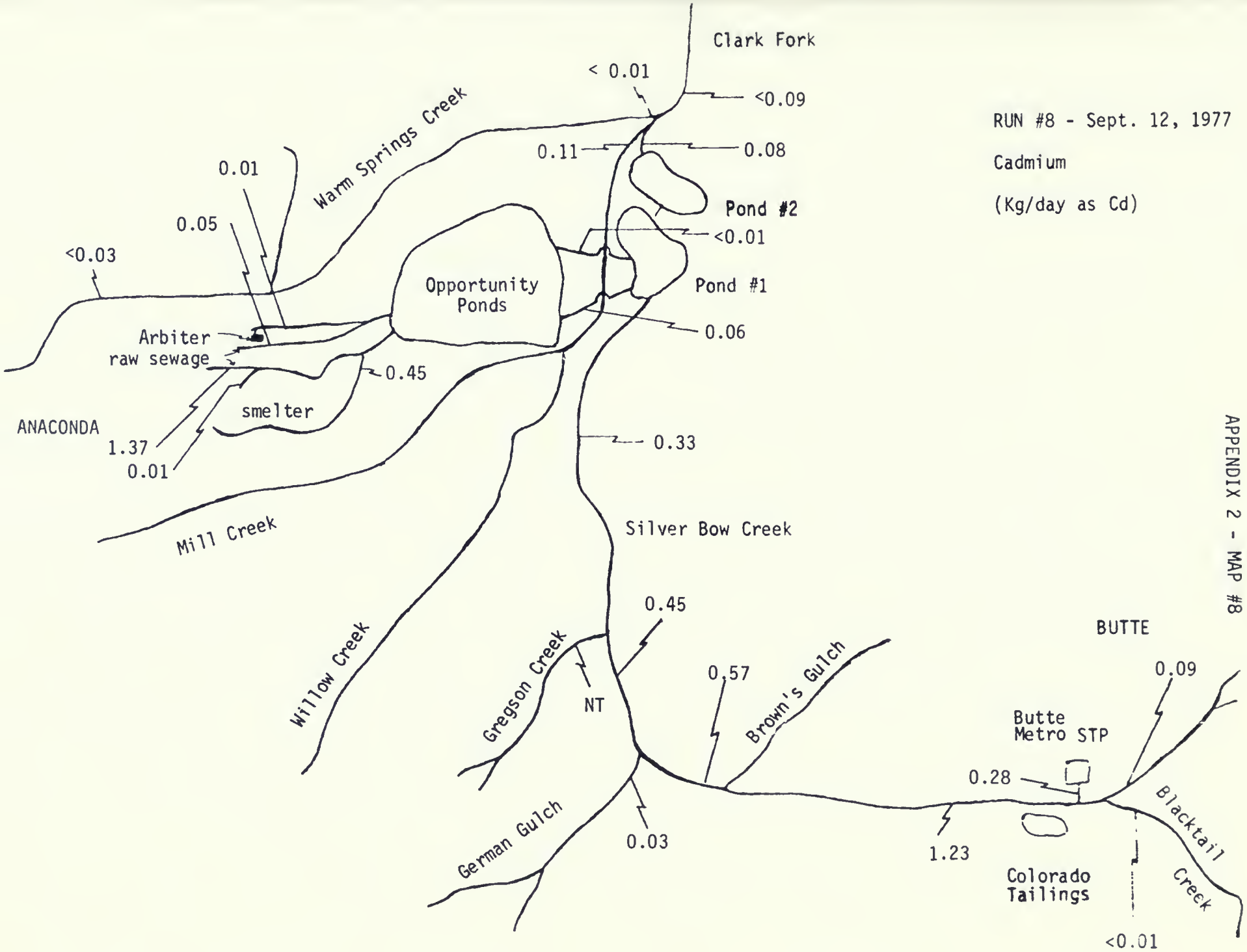
RUN #7 - August 29, 1977

Cadmium

(Kg/day as Cd)



APPENDIX 2 - MAP #8

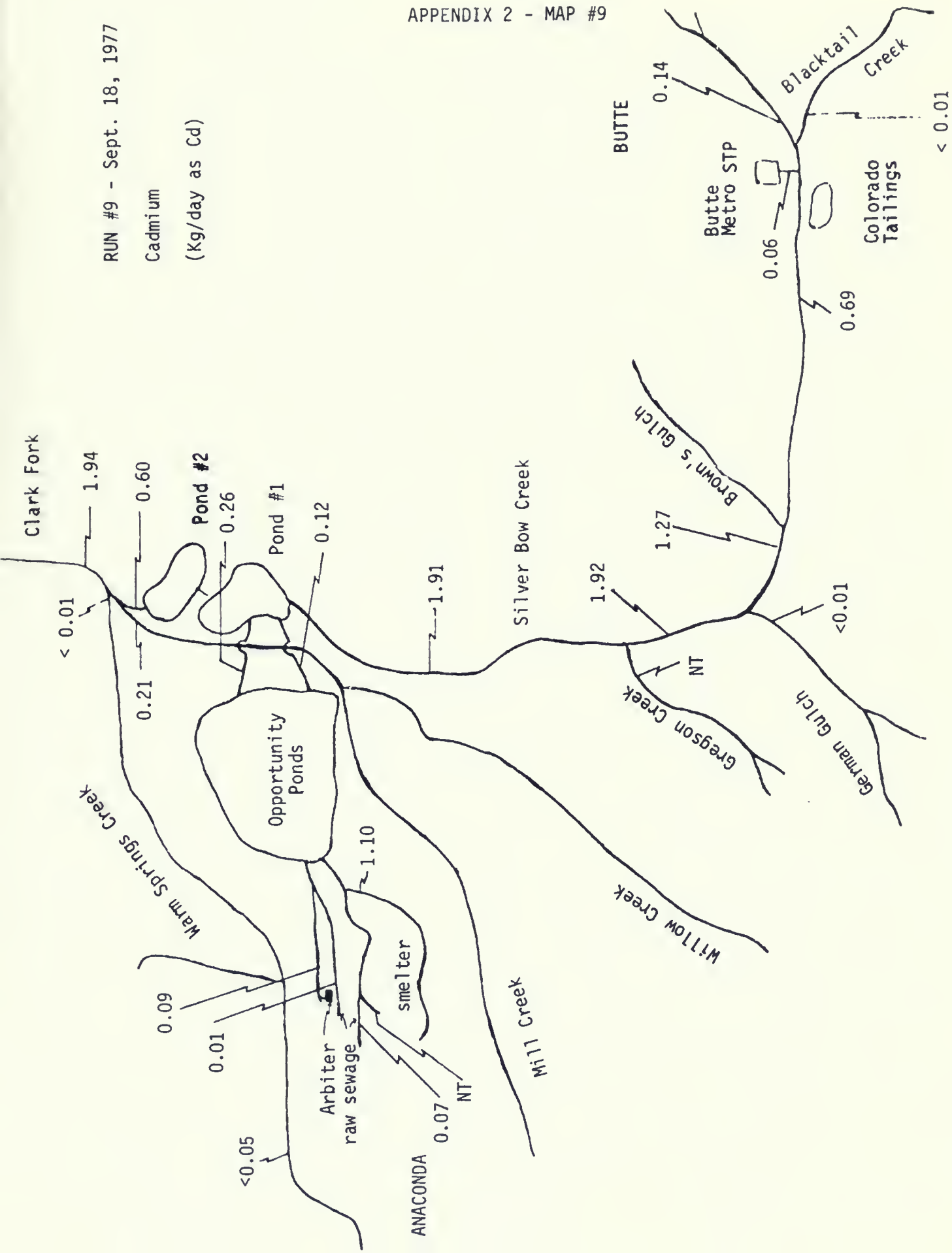


APPENDIX 2 - MAP #9

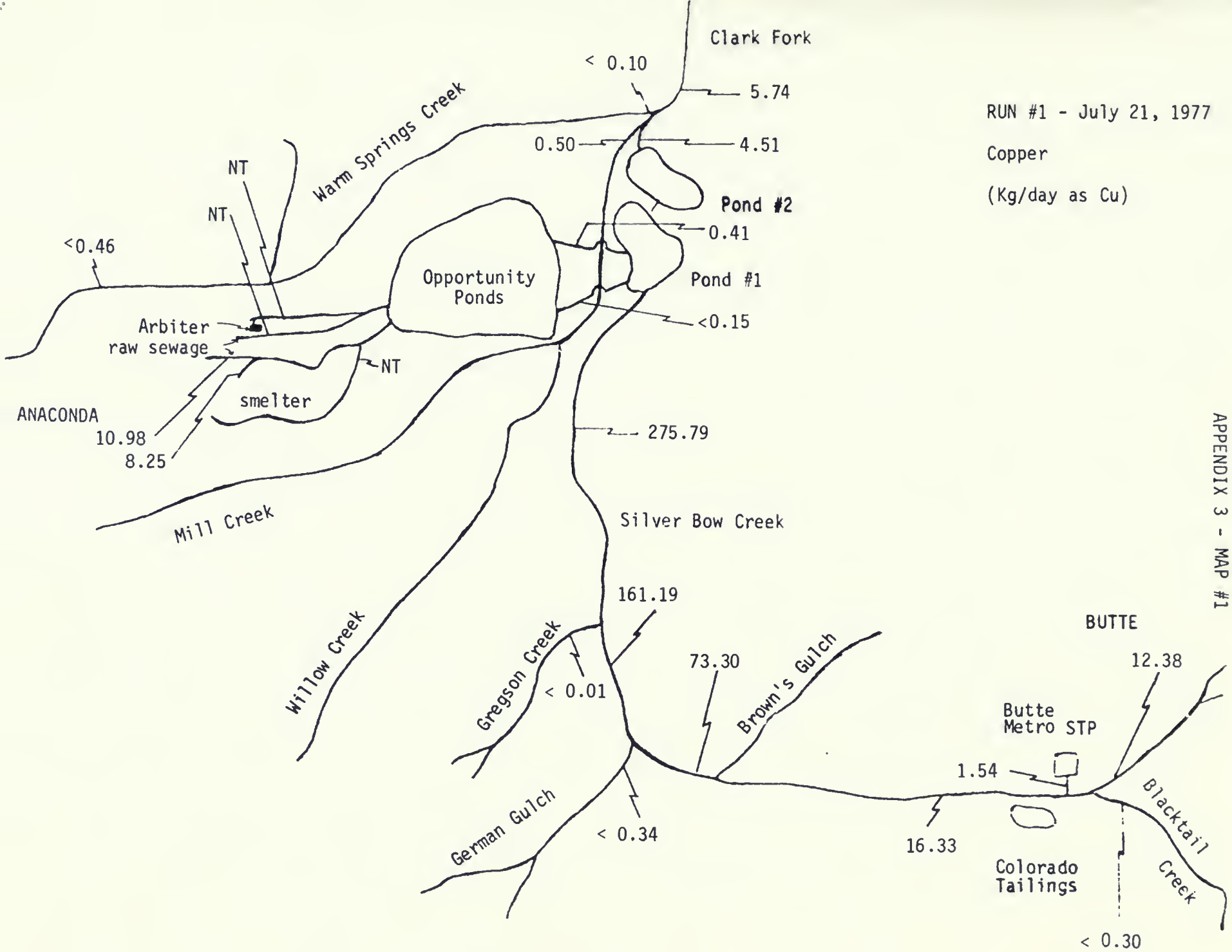
RUN #9 - Sept. 18, 1977

Cadmium

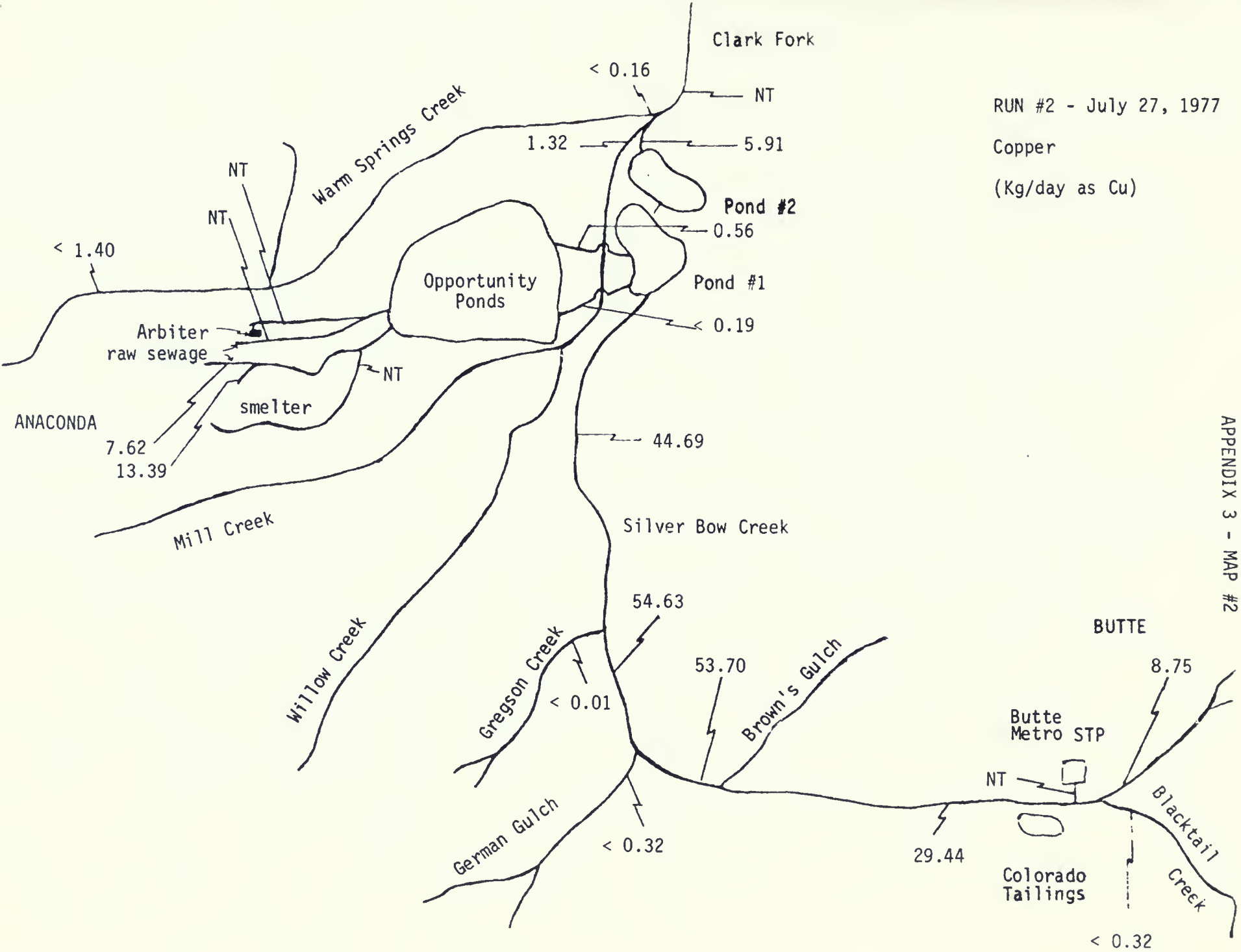
(Kg/day as Cd)

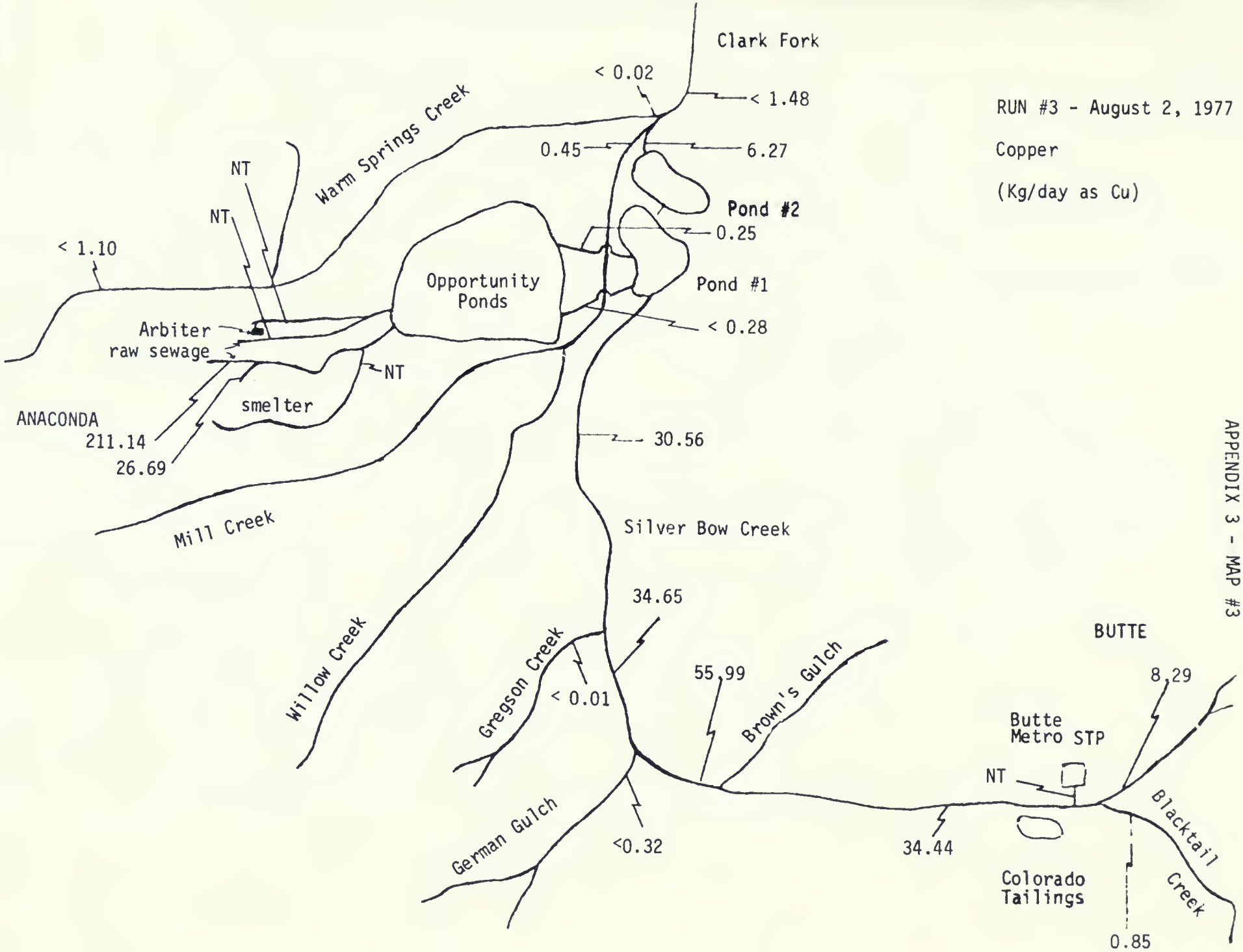


APPENDIX 3 - MAP #1



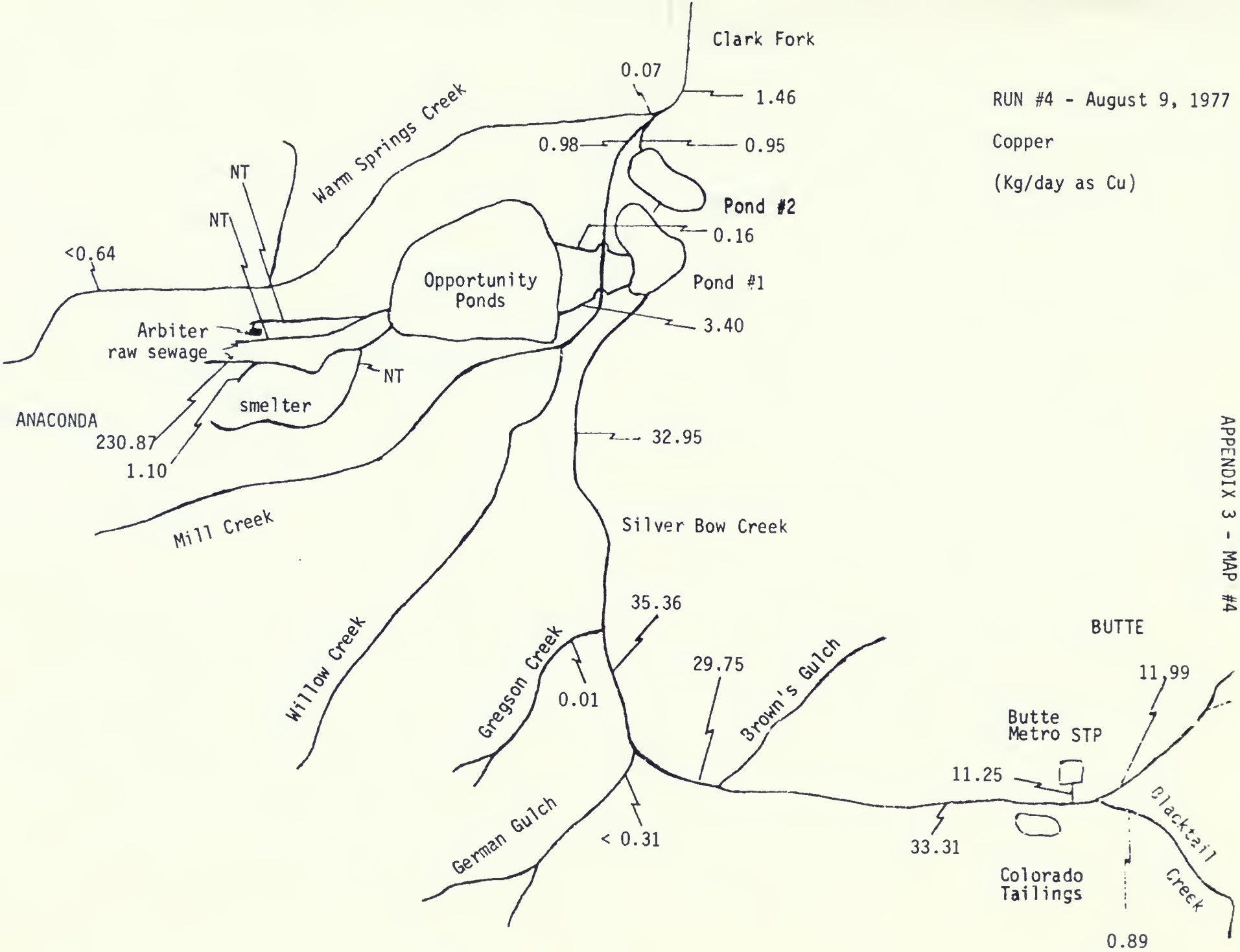
APPENDIX 3 - MAP #2



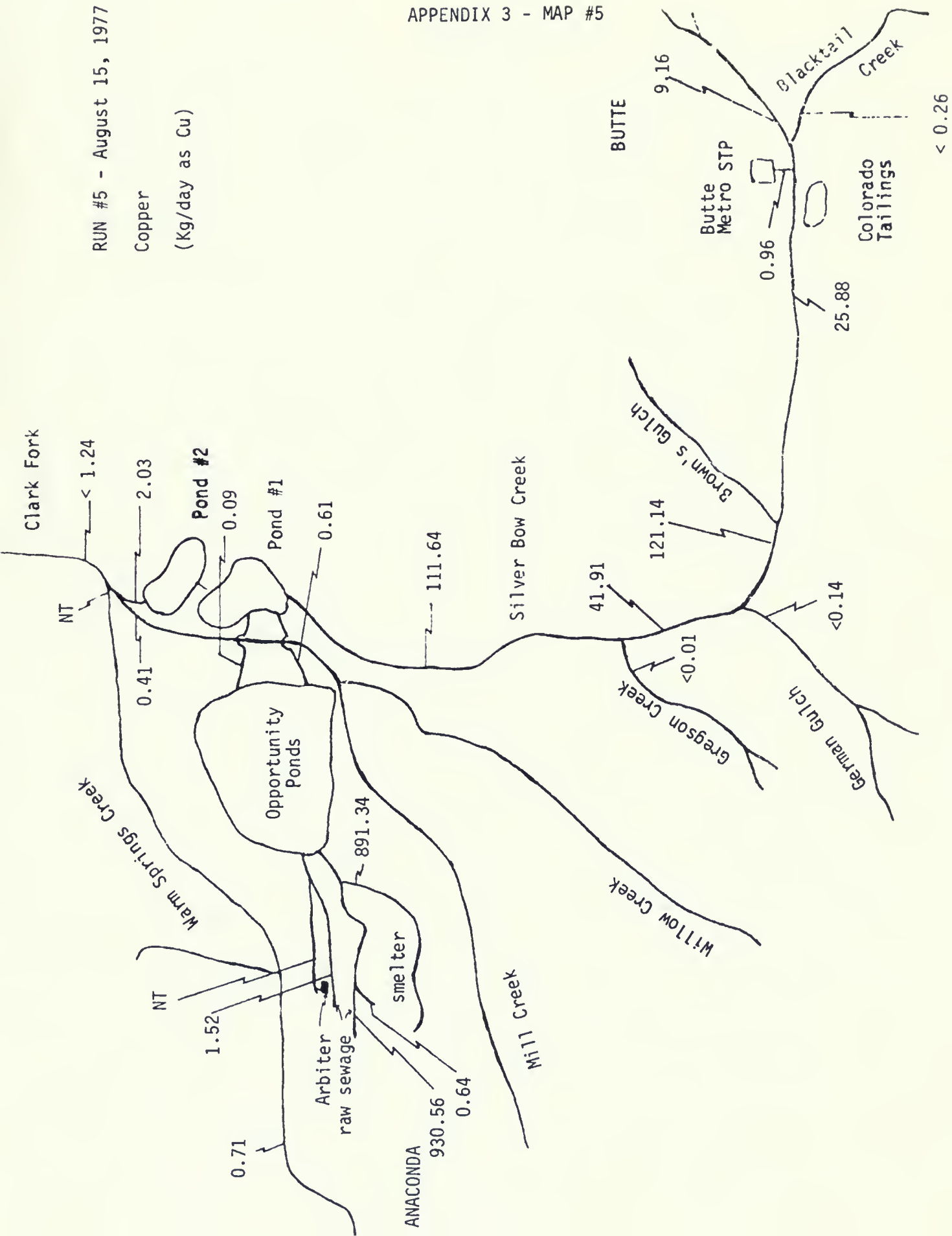


APPENDIX 3 - MAP #3

APPENDIX 3 - MAP #4



APPENDIX 3 - MAP #5

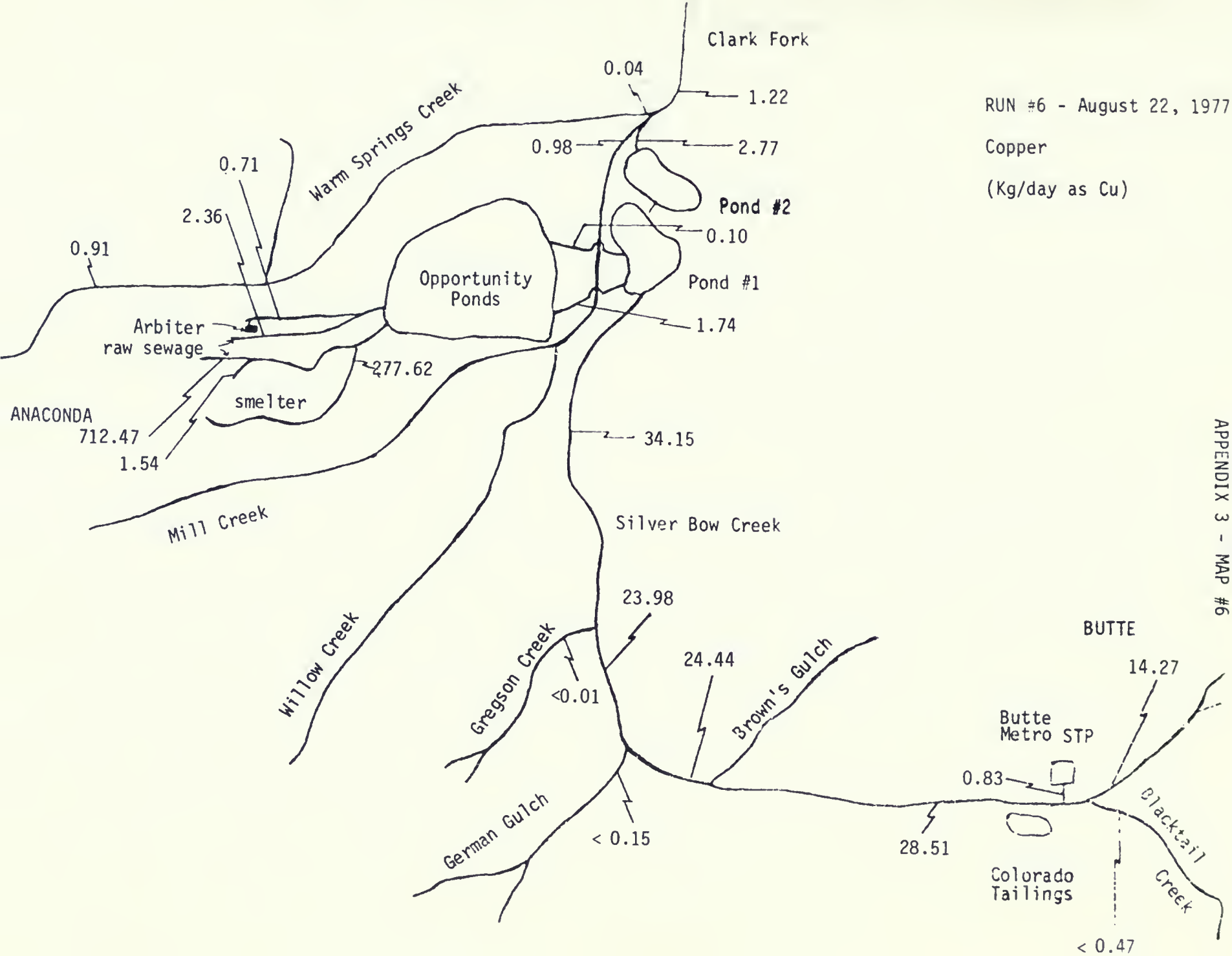


APPENDIX 3 - MAP #6

RUN #6 - August 22, 1977

Copper

(Kg/day as Cu)

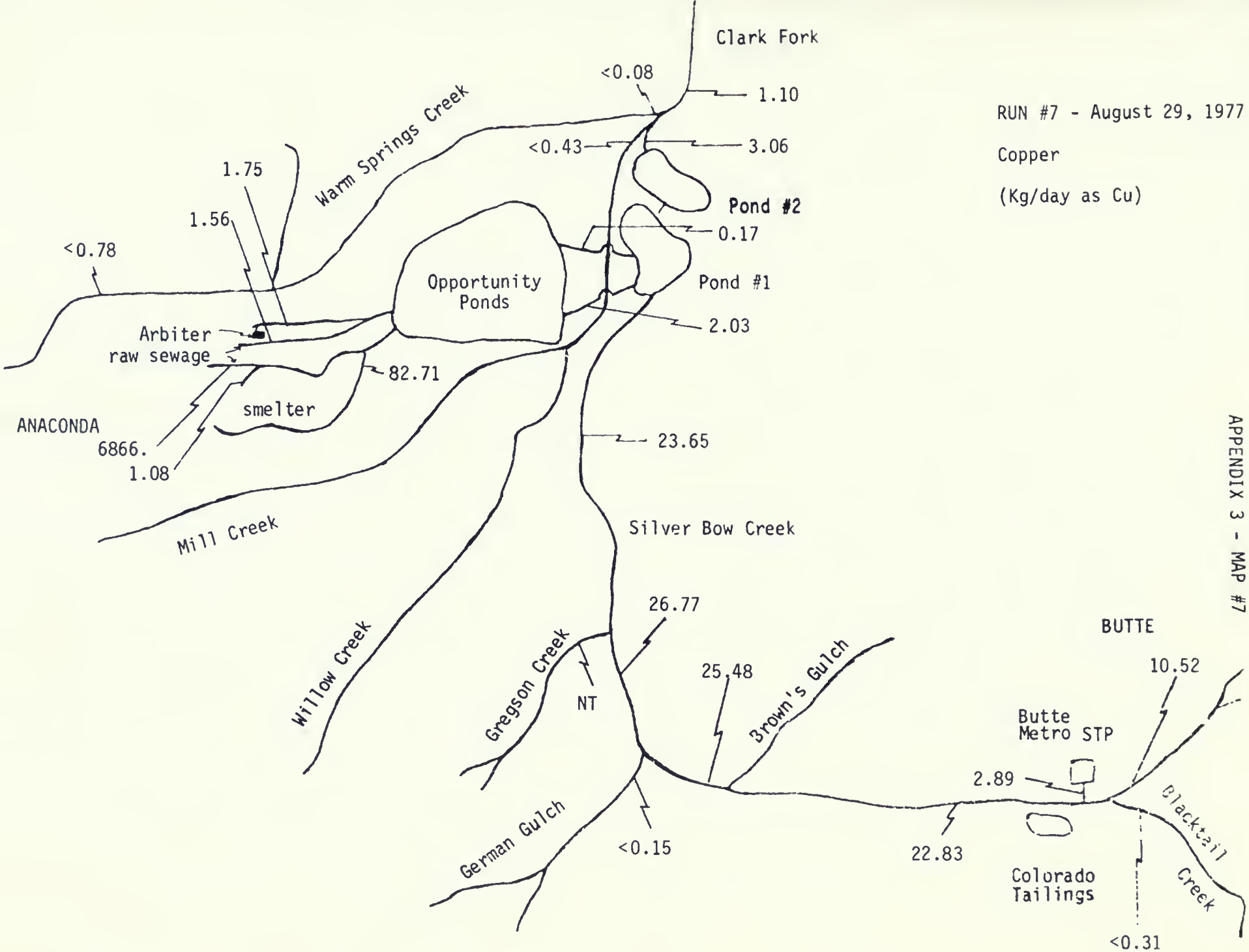


APPENDIX 3 - MAP #7

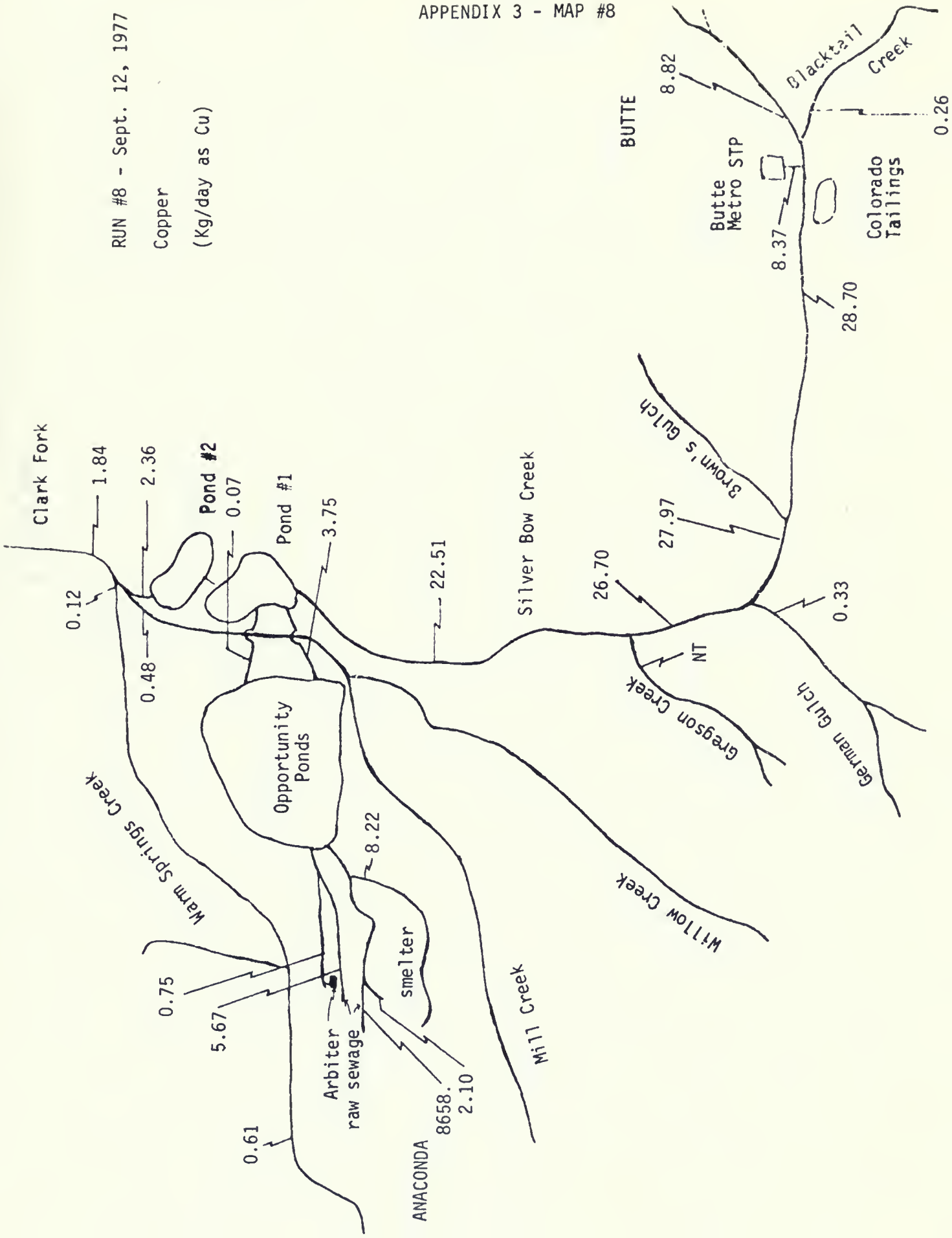
RUN #7 - August 29, 1977

Copper

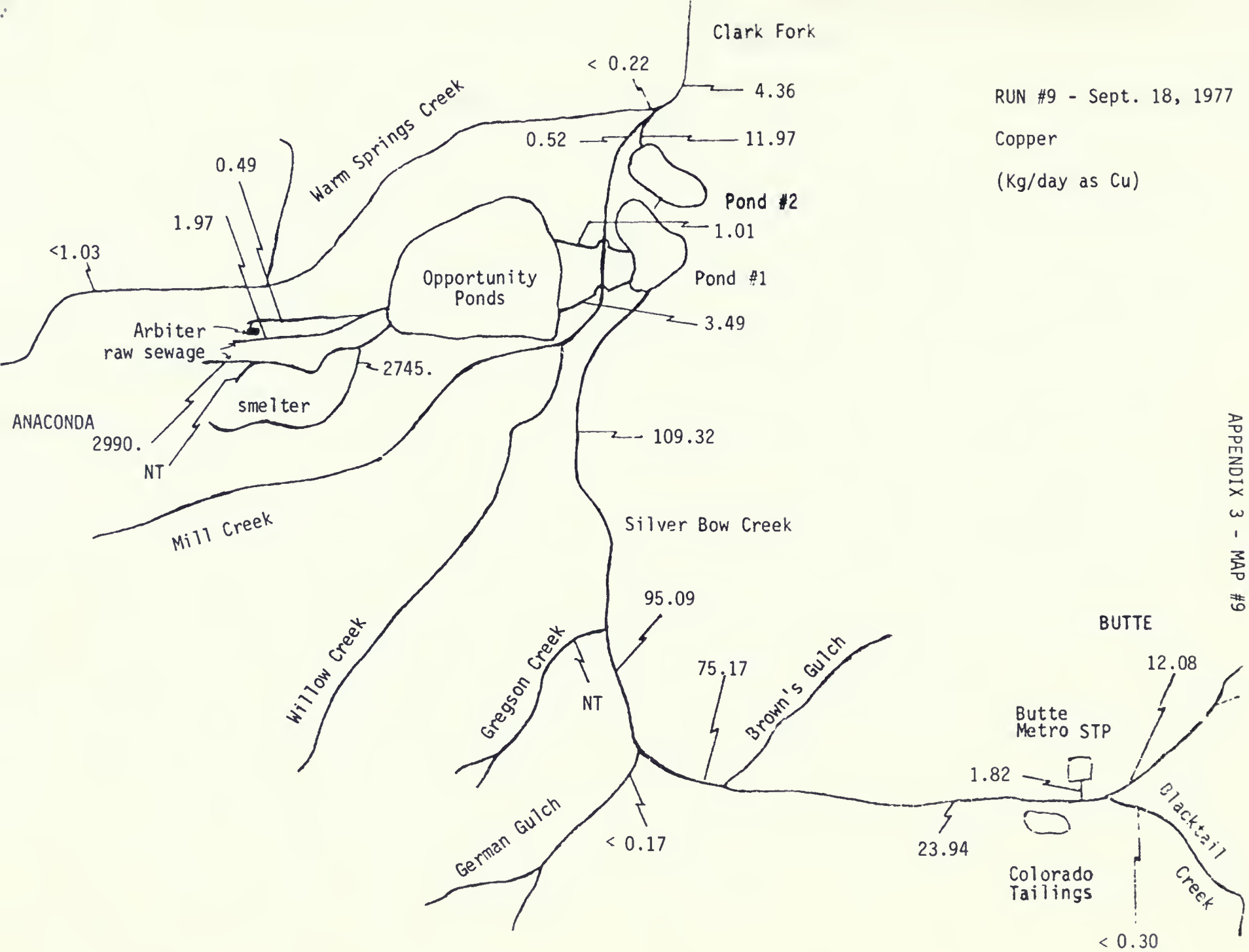
(Kg/day as Cu)



APPENDIX 3 - MAP #8



APPENDIX 3 - MAP #9

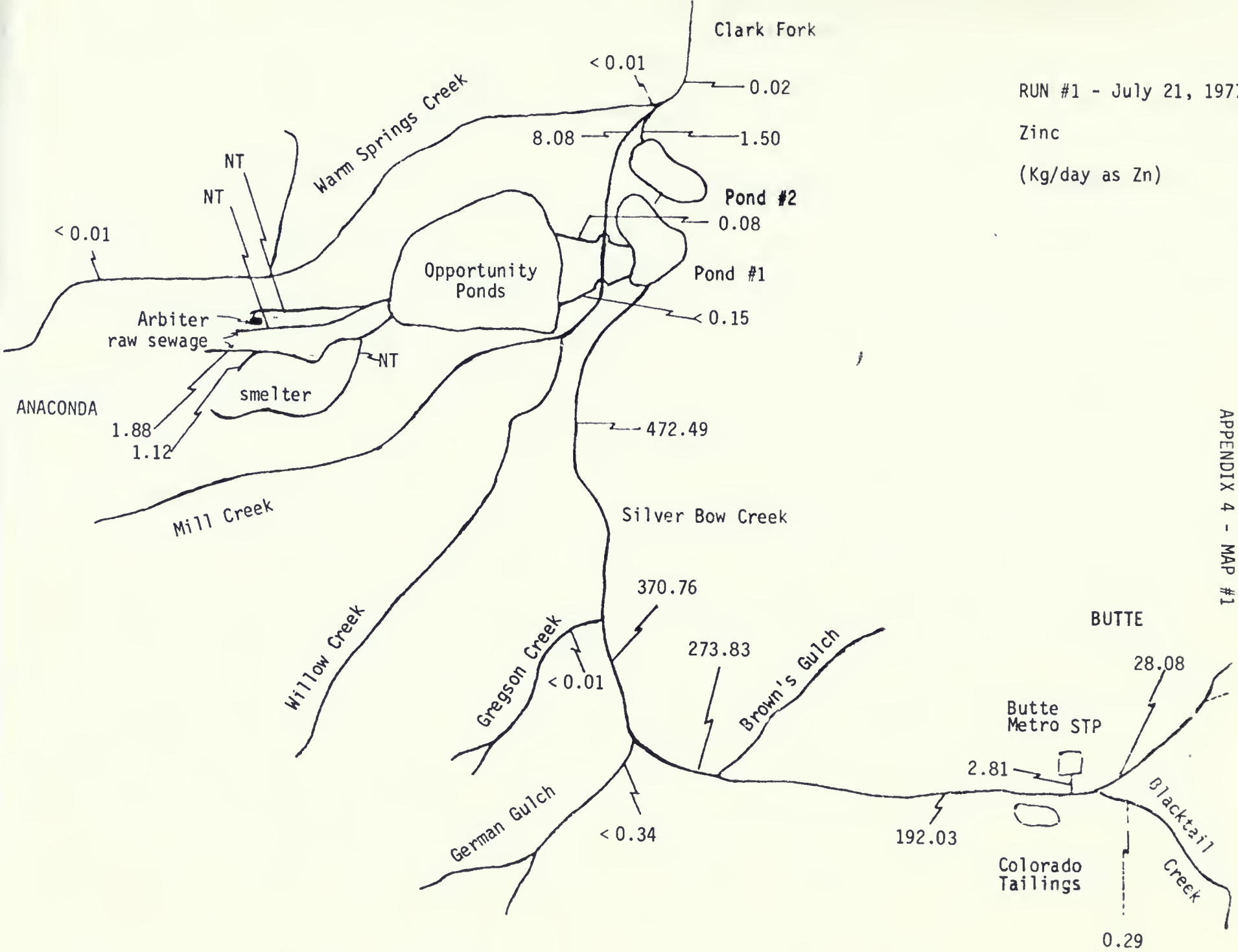


APPENDIX 4 - MAP #1

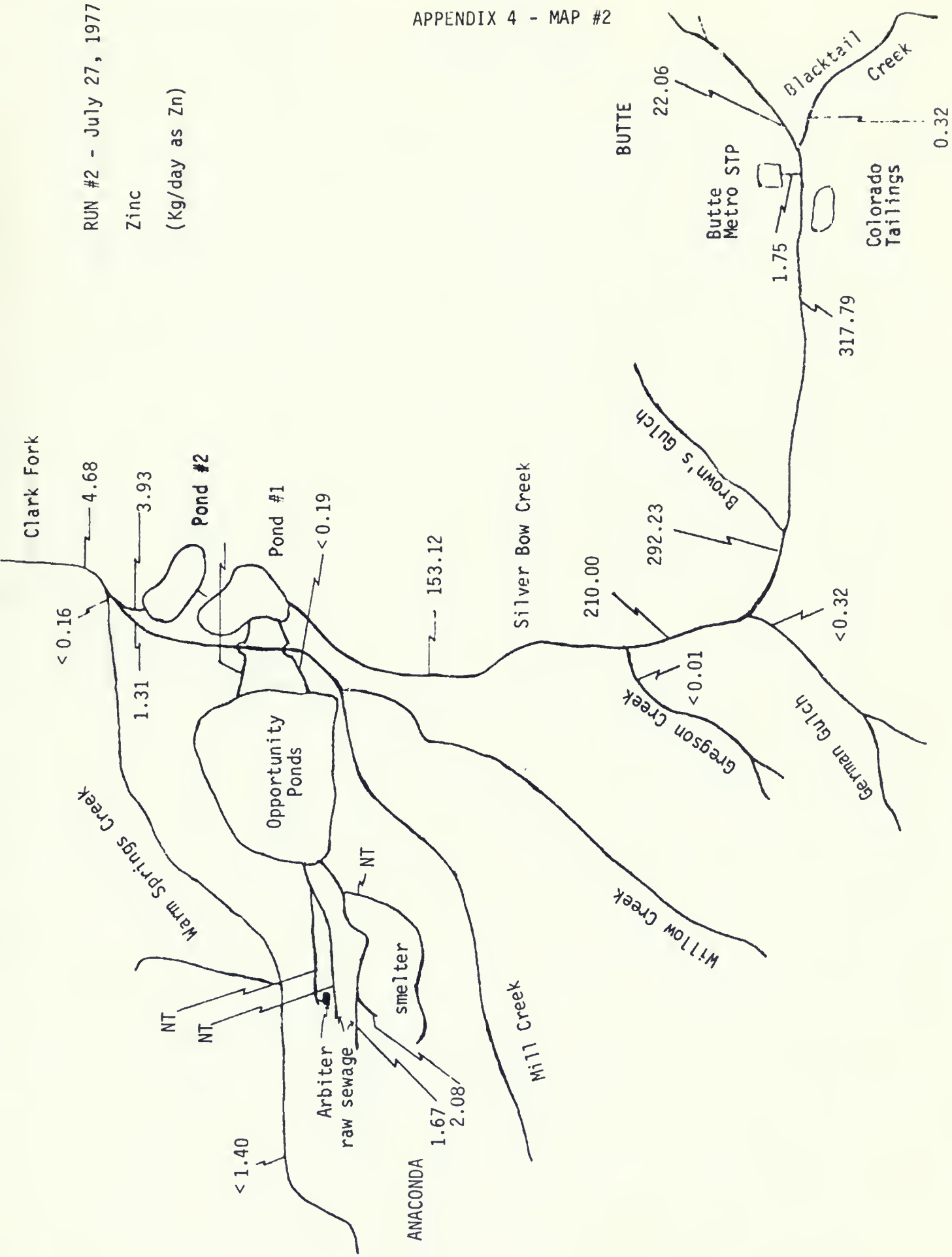
RUN #1 - July 21, 1977

Zinc

(Kg/day as Zn)



APPENDIX 4 - MAP #2

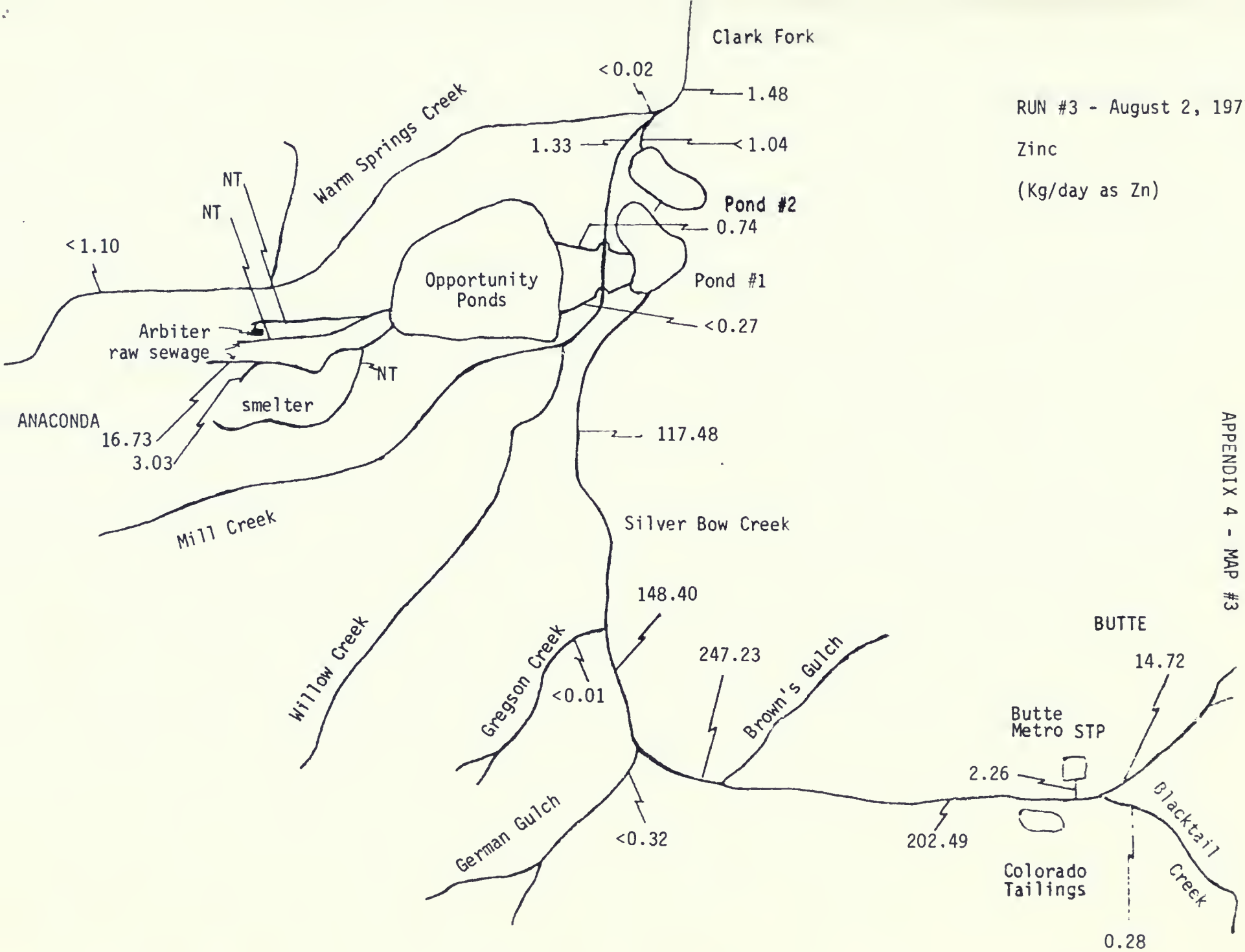


APPENDIX 4 - MAP #3

RUN #3 - August 2, 1977

Zinc

(Kg/day as Zn)

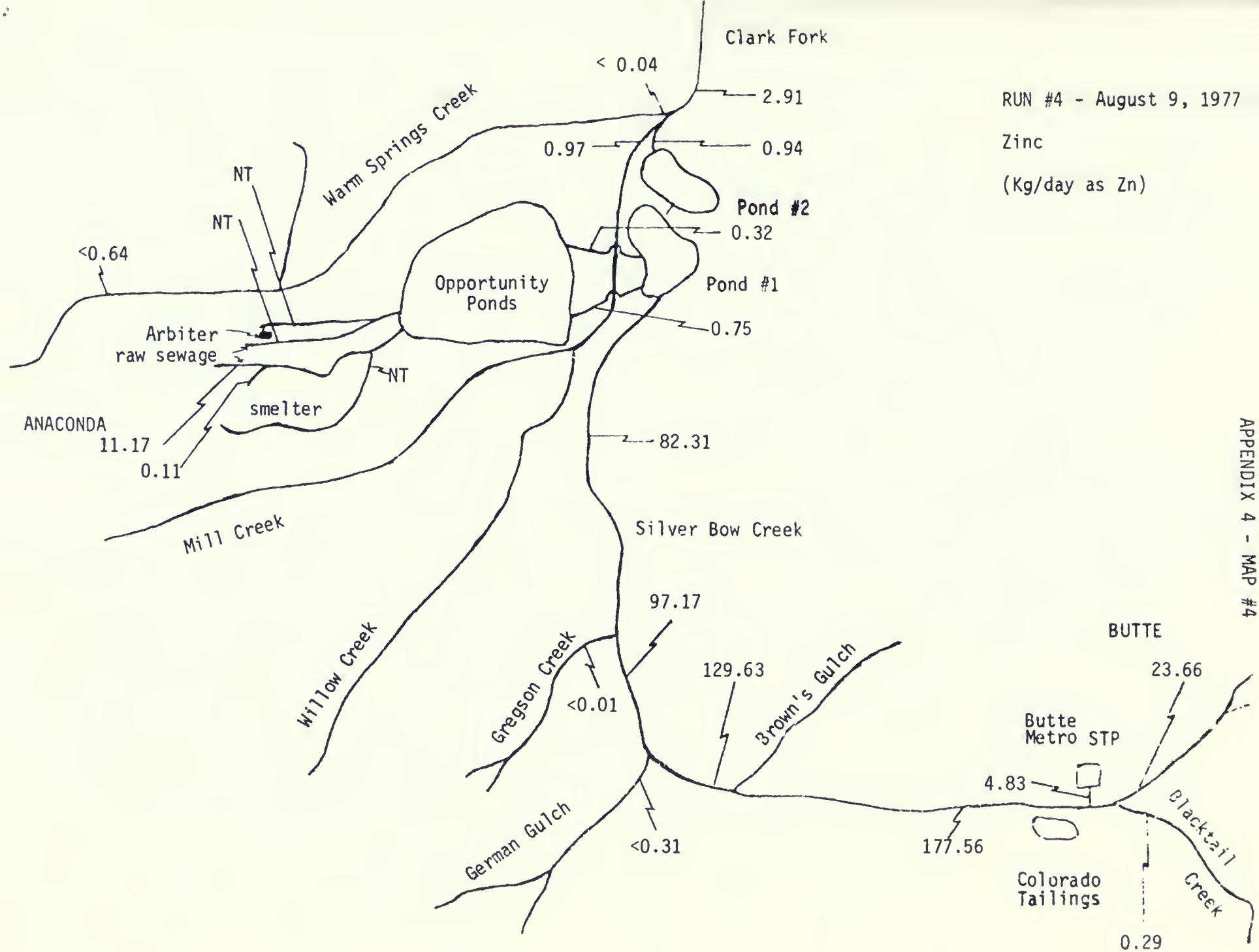


APPENDIX 4 - MAP #4

RUN #4 - August 9, 1977

Zinc

(Kg/day as Zn)

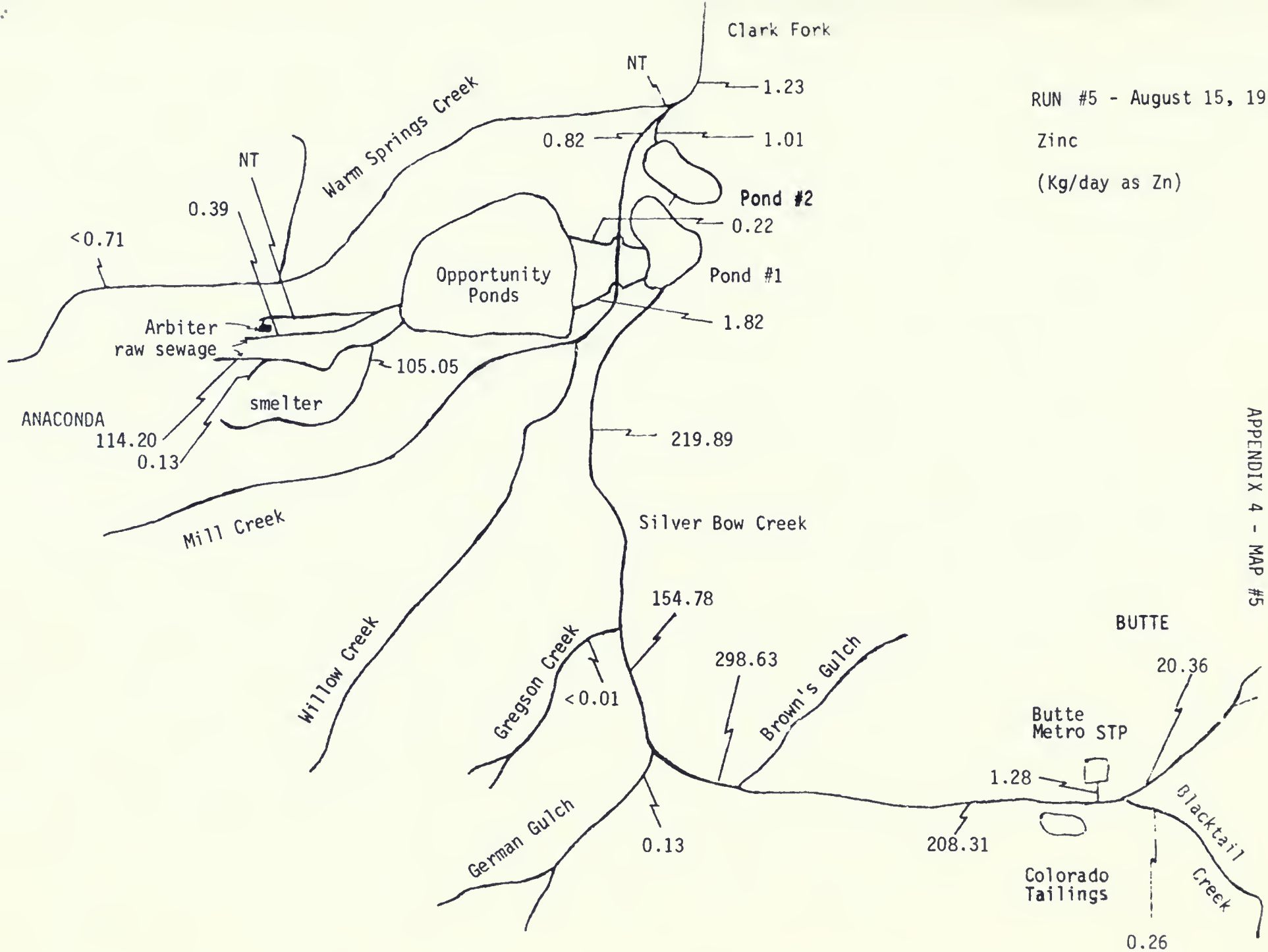


APPENDIX 4 - MAP #5

RUN #5 - August 15, 1977

Zinc

(Kg/day as Zn)

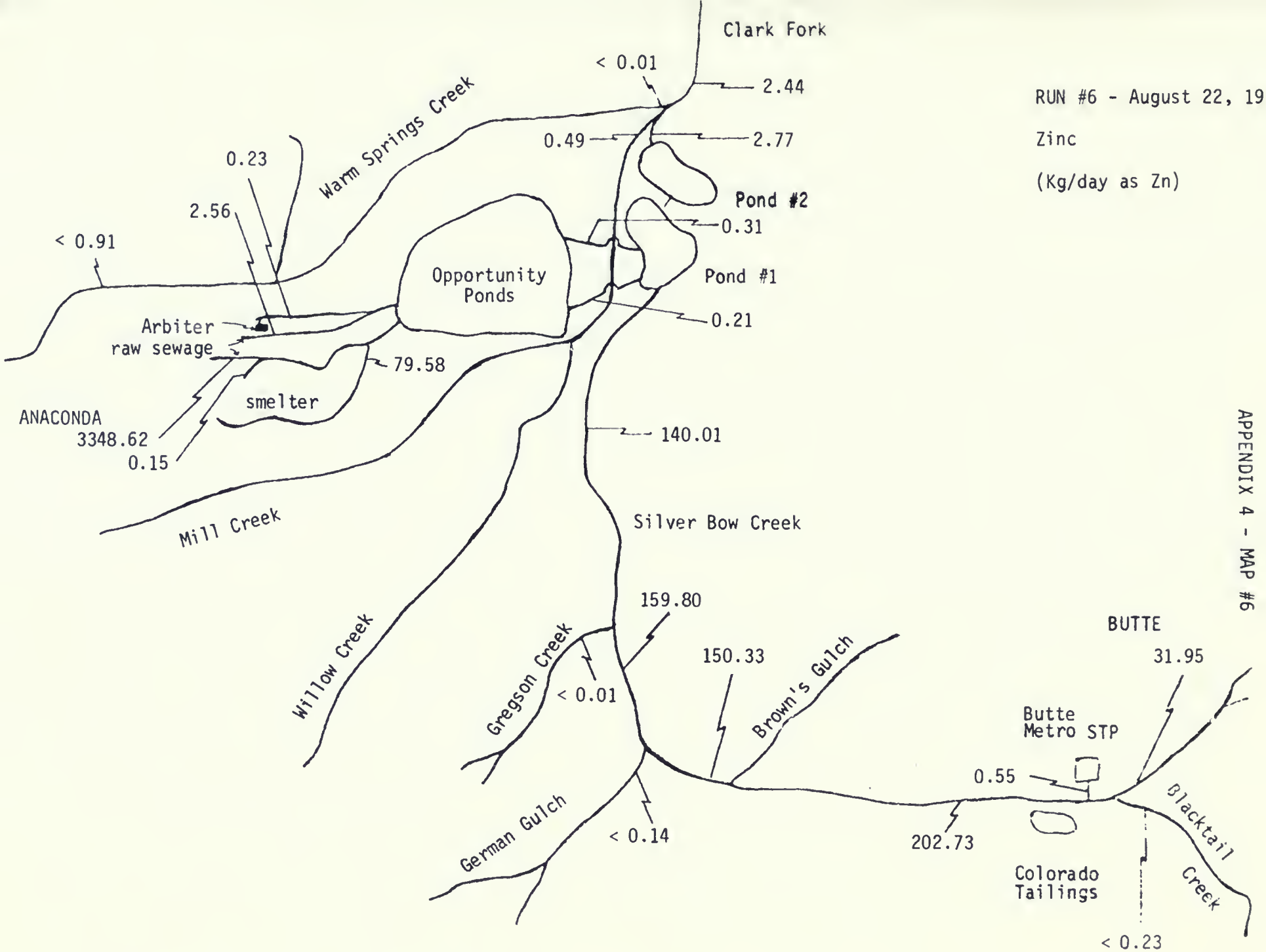


APPENDIX 4 - MAP #6

RUN #6 - August 22, 1977

Zinc

(Kg/day as Zn)

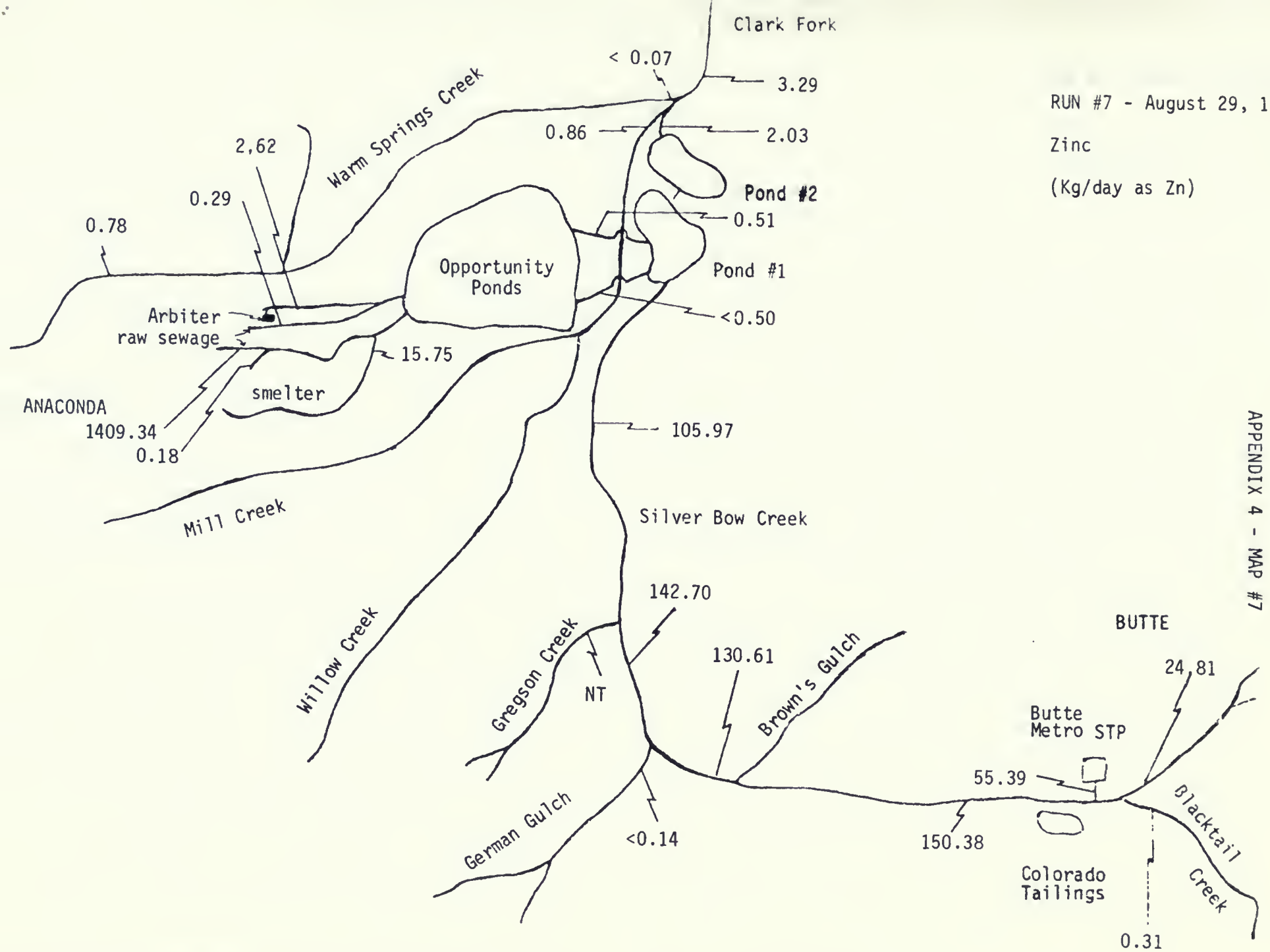


APPENDIX 4 - MAP #7

RUN #7 - August 29, 1977

Zinc

(Kg/day as Zn)

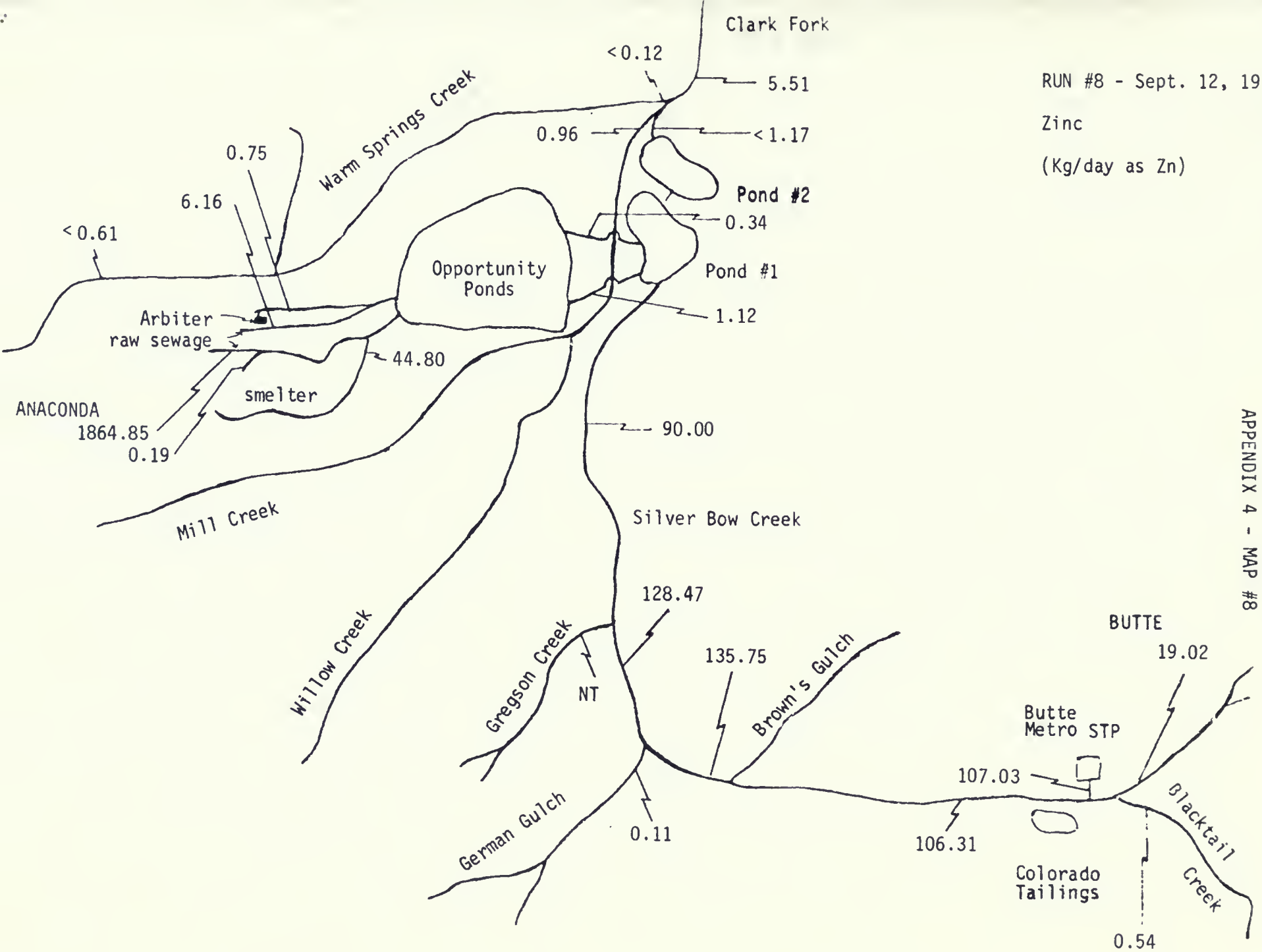


APPENDIX 4 - MAP #8

RUN #8 - Sept. 12, 1977

Zinc

(Kg/day as Zn)

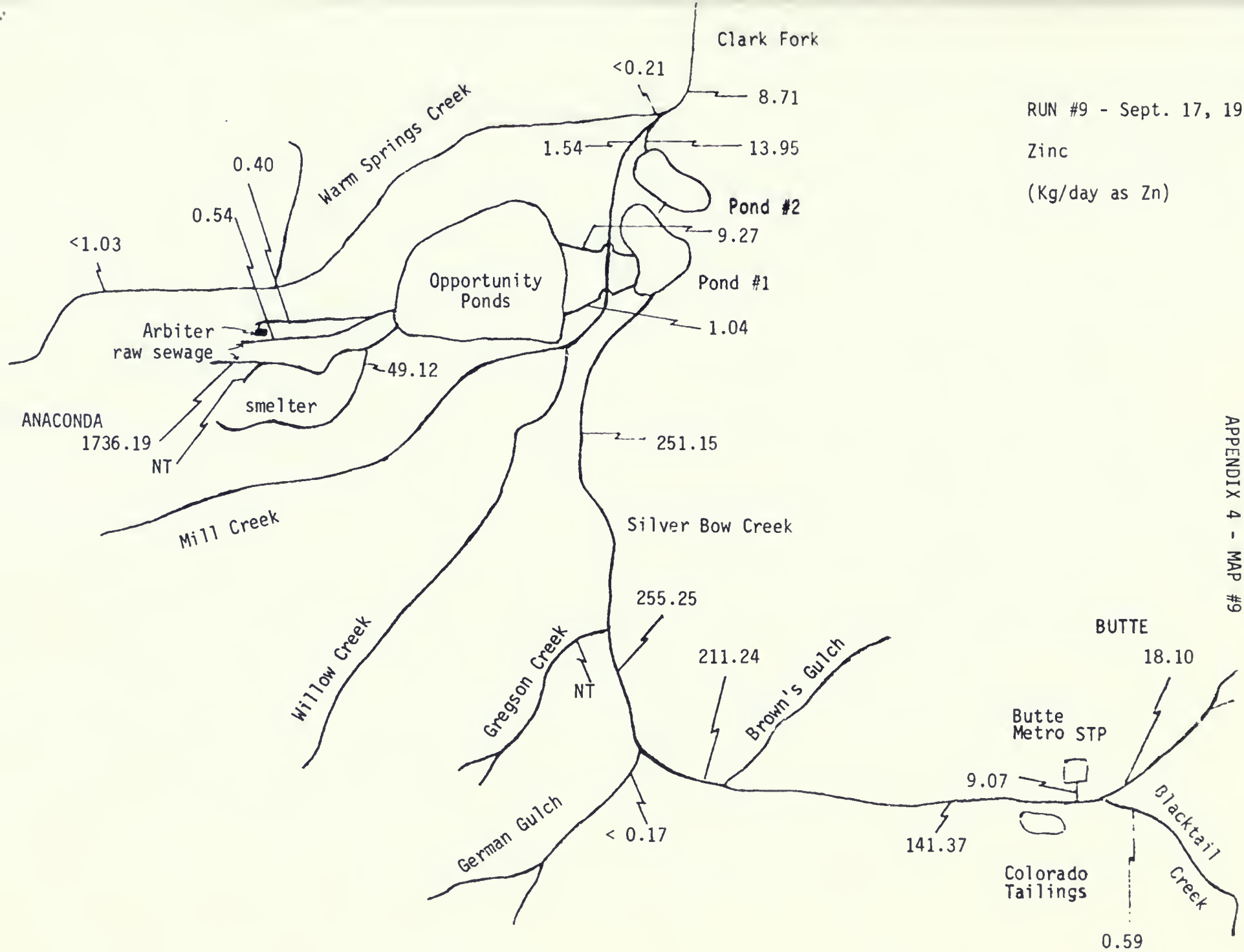


APPENDIX 4 - MAP #9

RUN #9 - Sept. 17, 1977

Zinc

(Kg/day as Zn)

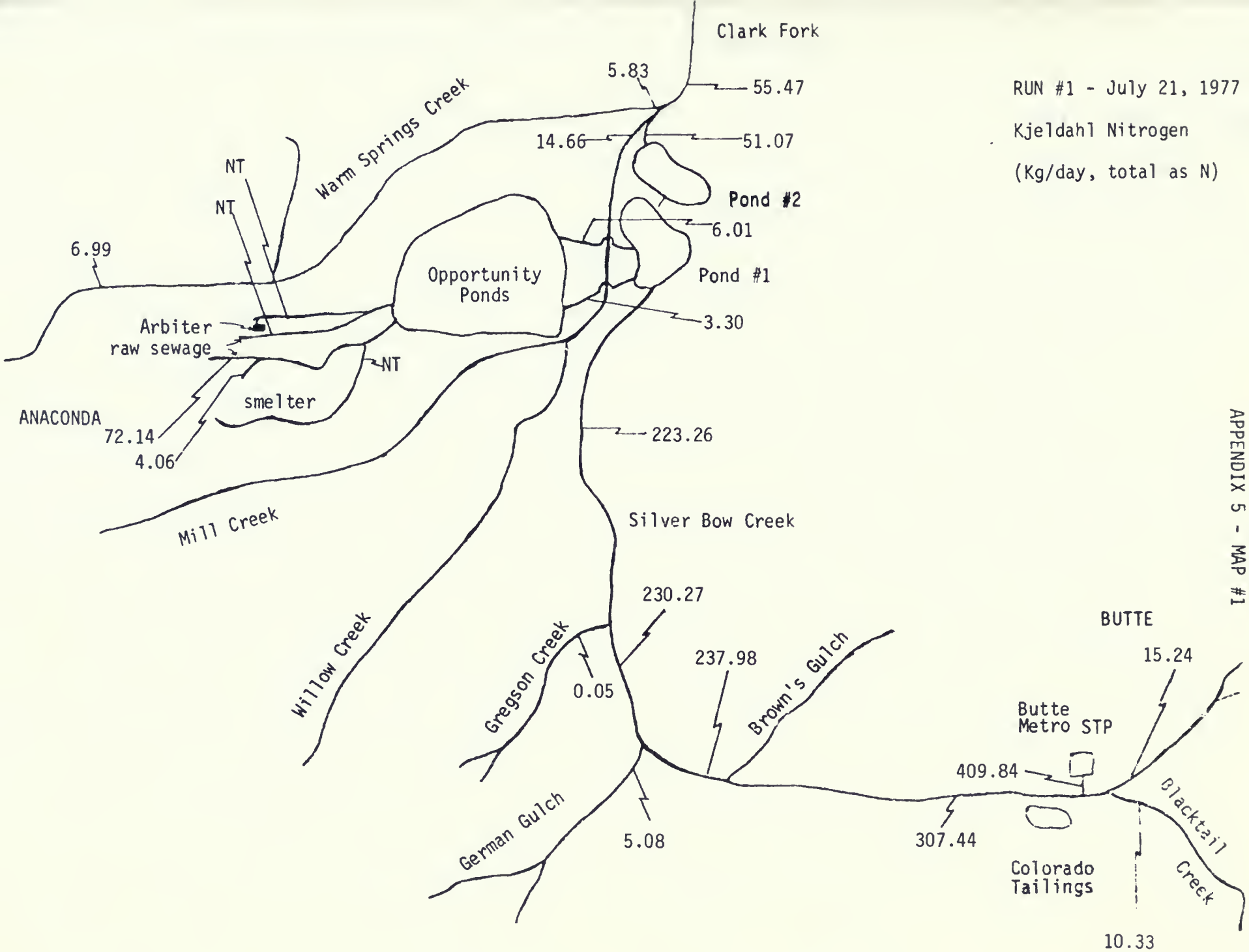


APPENDIX 5 - MAP #1

RUN #1 - July 21, 1977

Kjeldahl Nitrogen

(Kg/day, total as N)

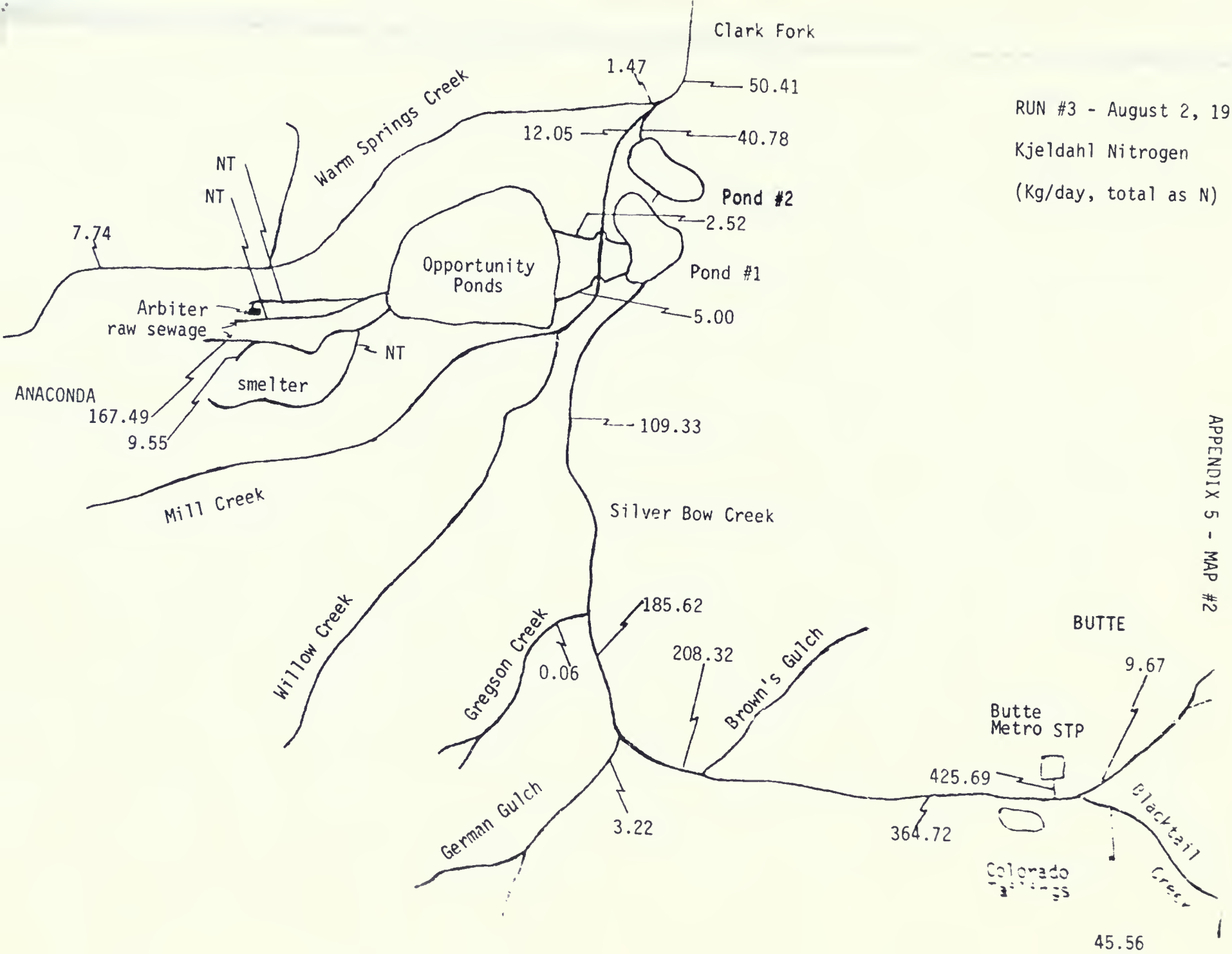


APPENDIX 5 - MAP #2

RUN #3 - August 2, 1977

Kjeldahl Nitrogen

(Kg/day, total as N)

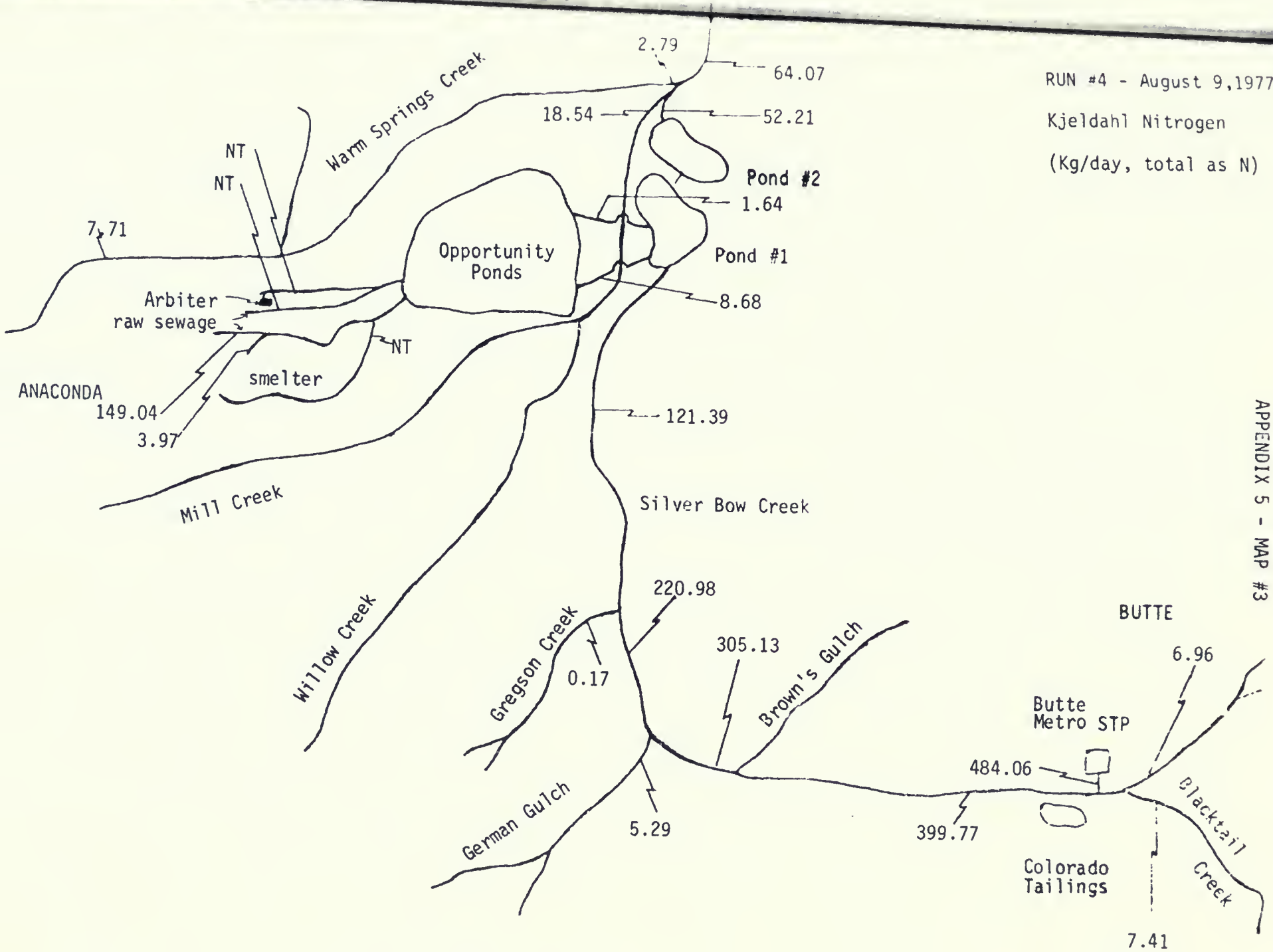


APPENDIX 5 - MAP #3

RUN #4 - August 9,1977

Kjeldahl Nitrogen

(Kg/day, total as N)

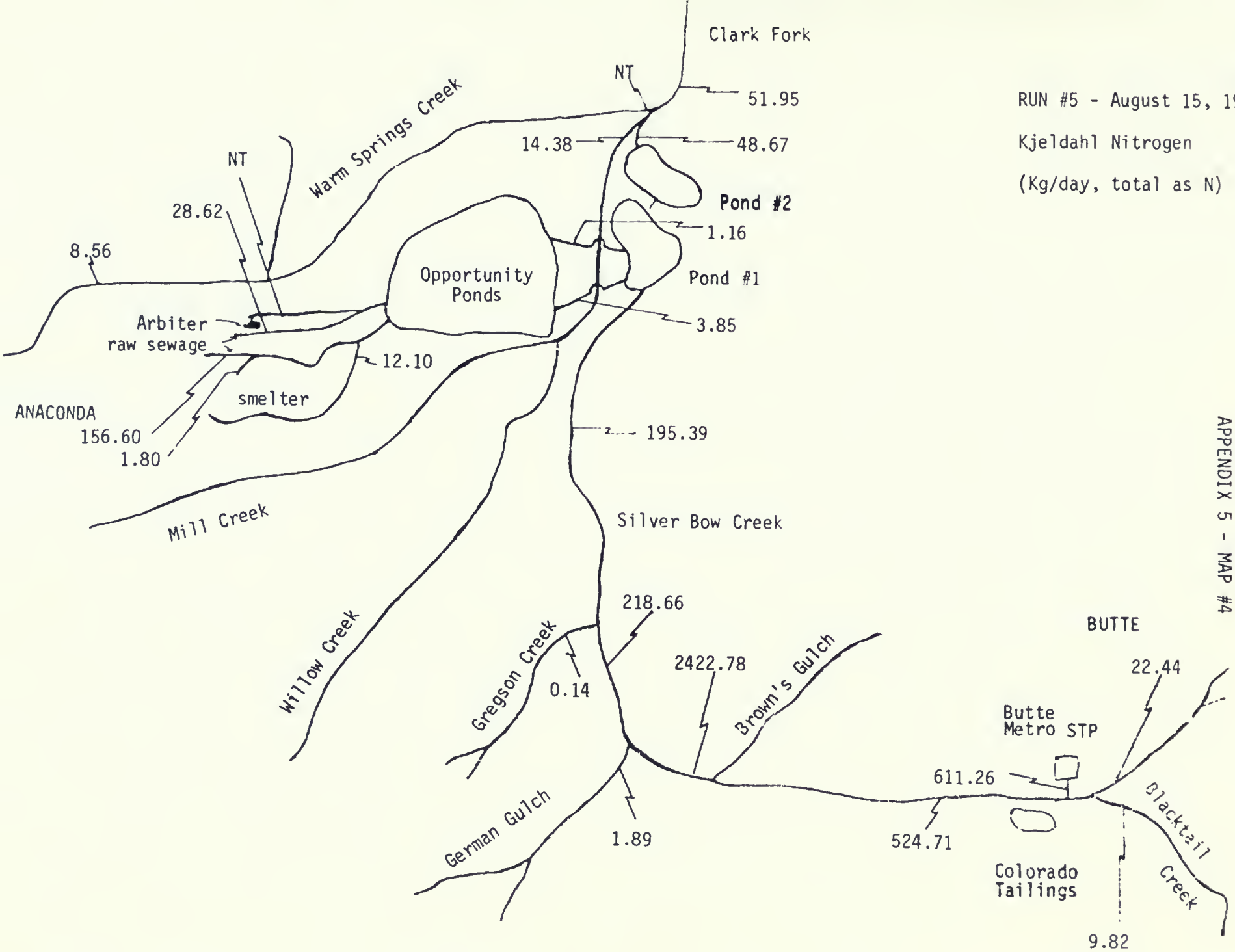


APPENDIX 5 - MAP #4

RUN #5 - August 15, 1977

Kjeldahl Nitrogen

(Kg/day, total as N)

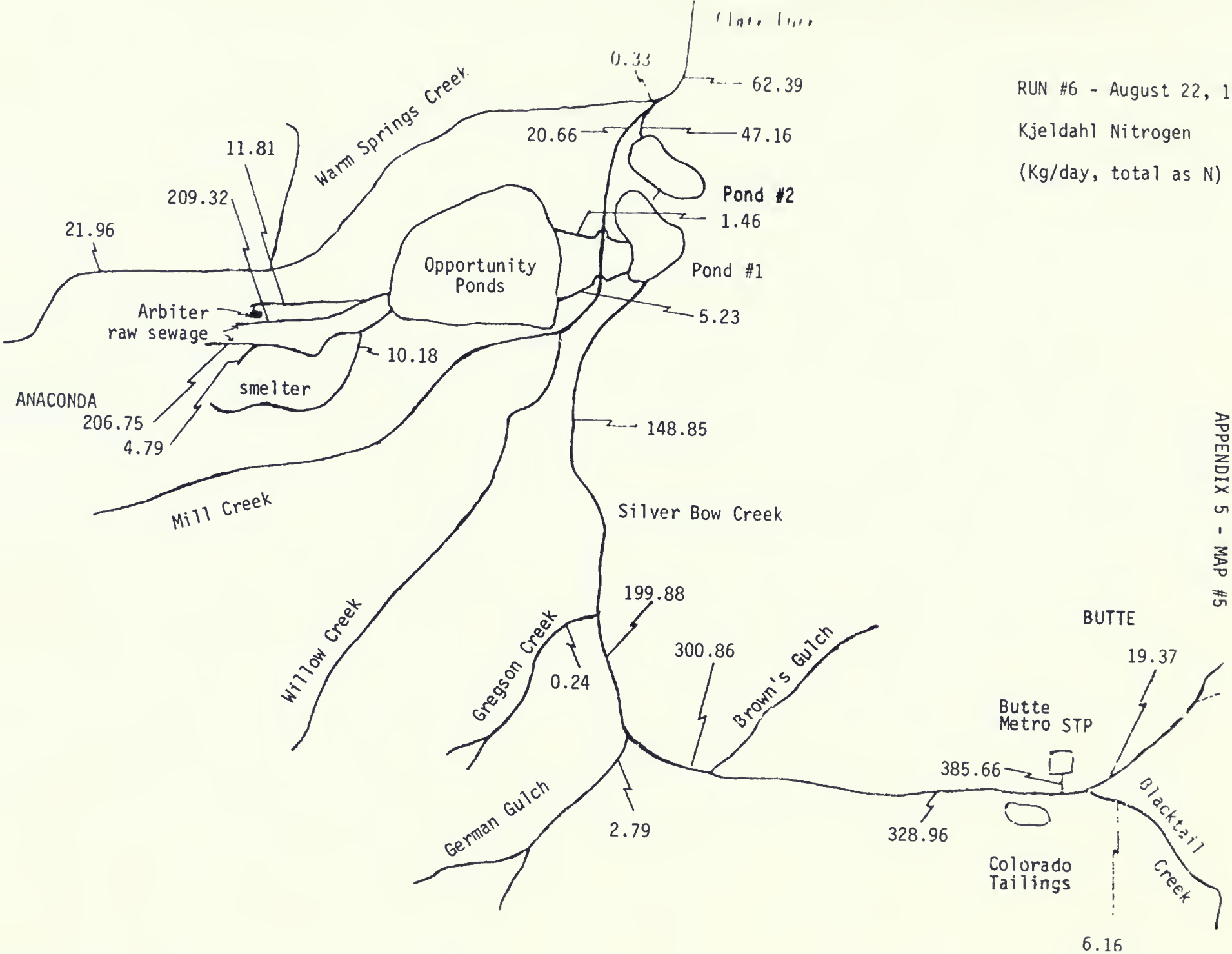


APPENDIX 5 - MAP #5

RUN #6 - August 22, 1977

Kjeldahl Nitrogen

(Kg/day, total as N)

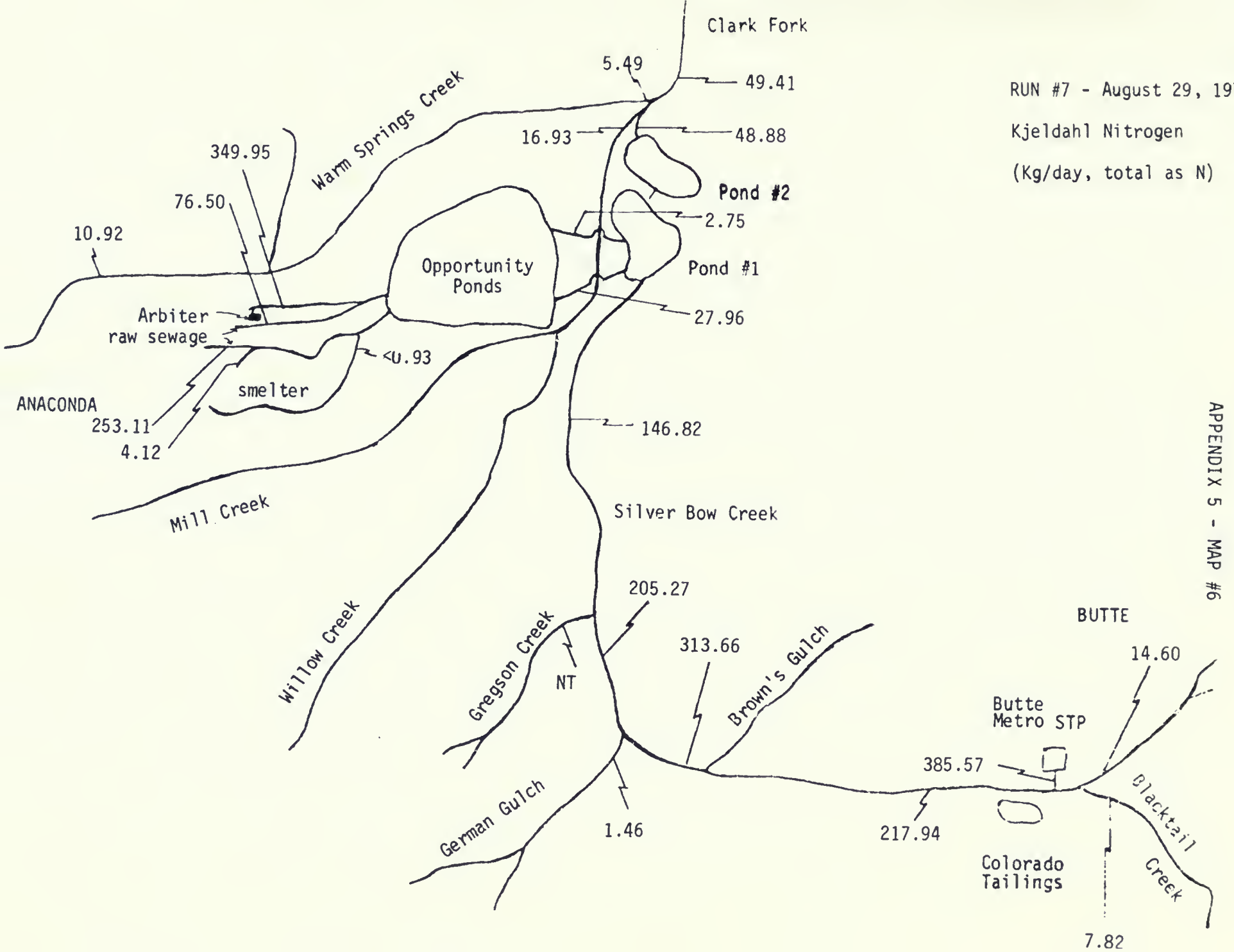


APPENDIX 5 - MAP #6

RUN #7 - August 29, 1977

Kjeldahl Nitrogen

(Kg/day, total as N)

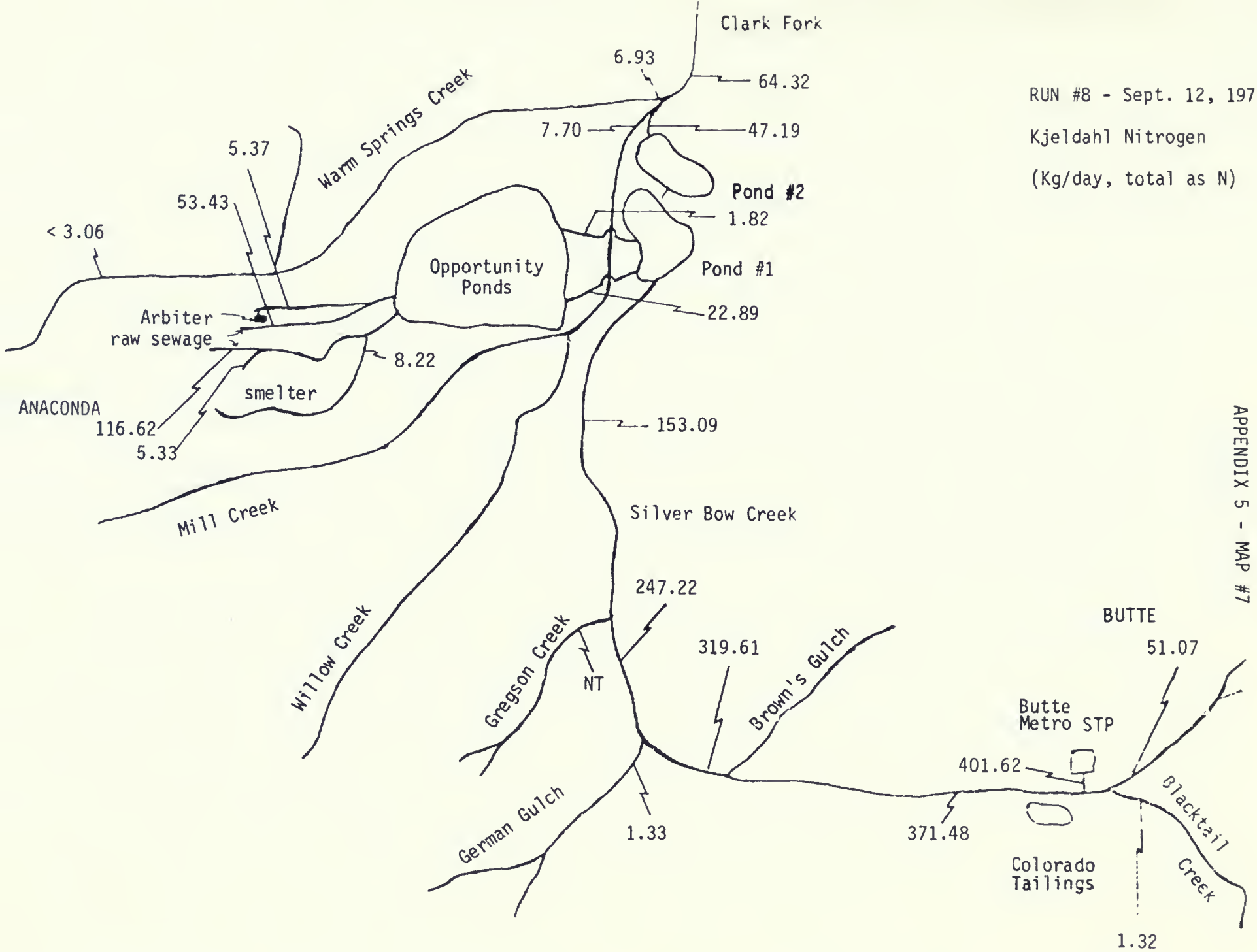


APPENDIX 5 - MAP #7

RUN #8 - Sept. 12, 1977

Kjeldahl Nitrogen

(Kg/day, total as N)

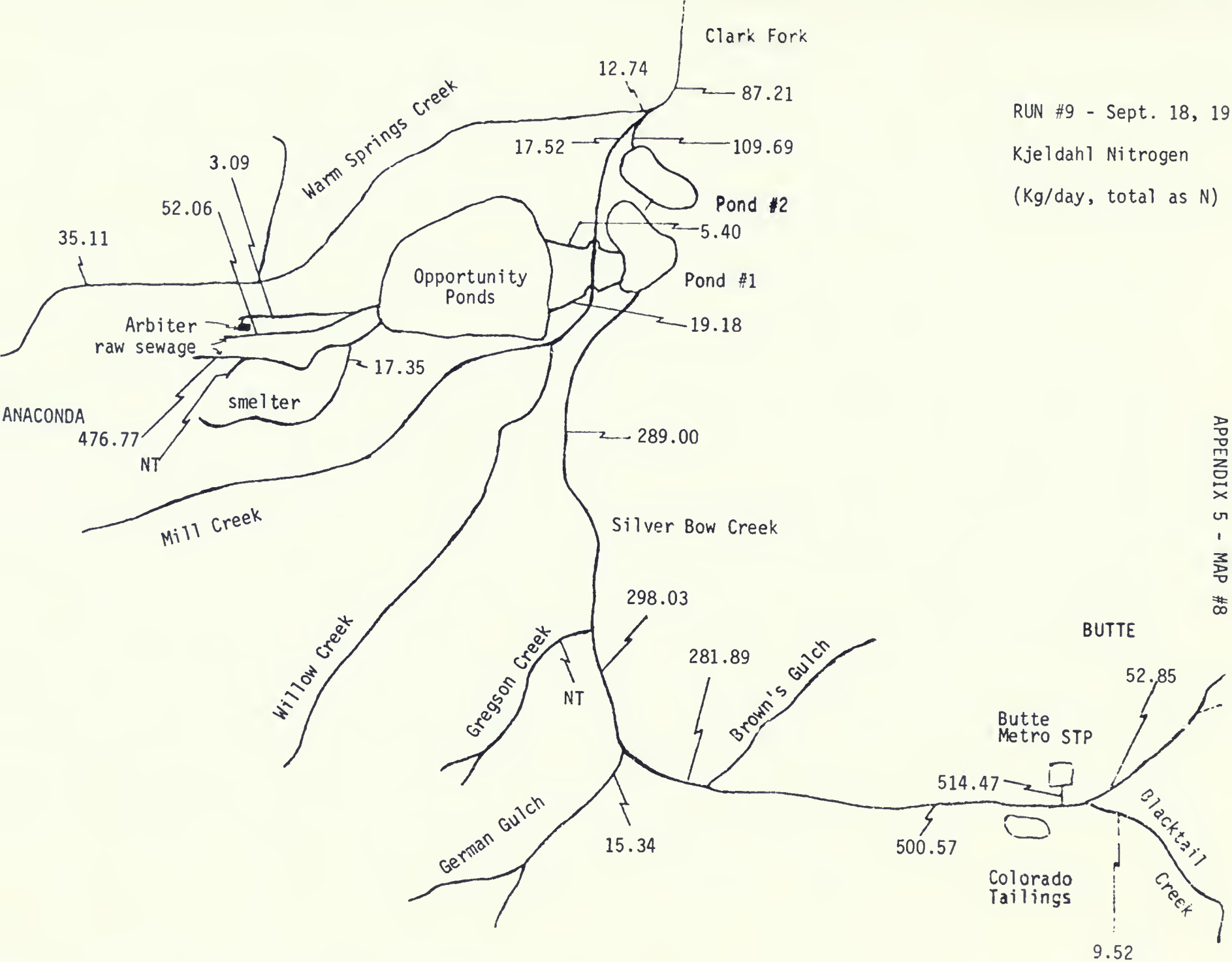


APPENDIX 5 - MAP #8

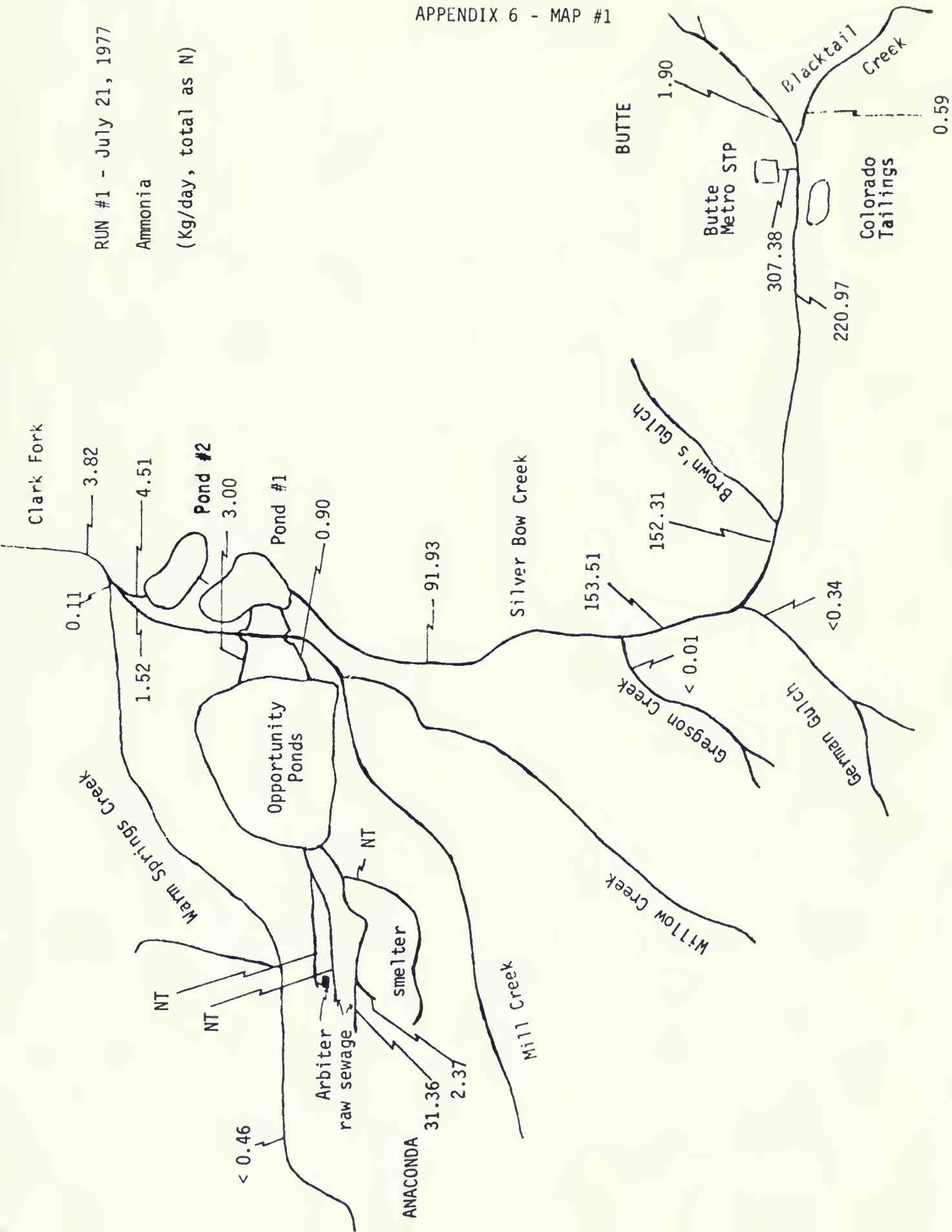
RUN #9 - Sept. 18, 1977

Kjeldahl Nitrogen

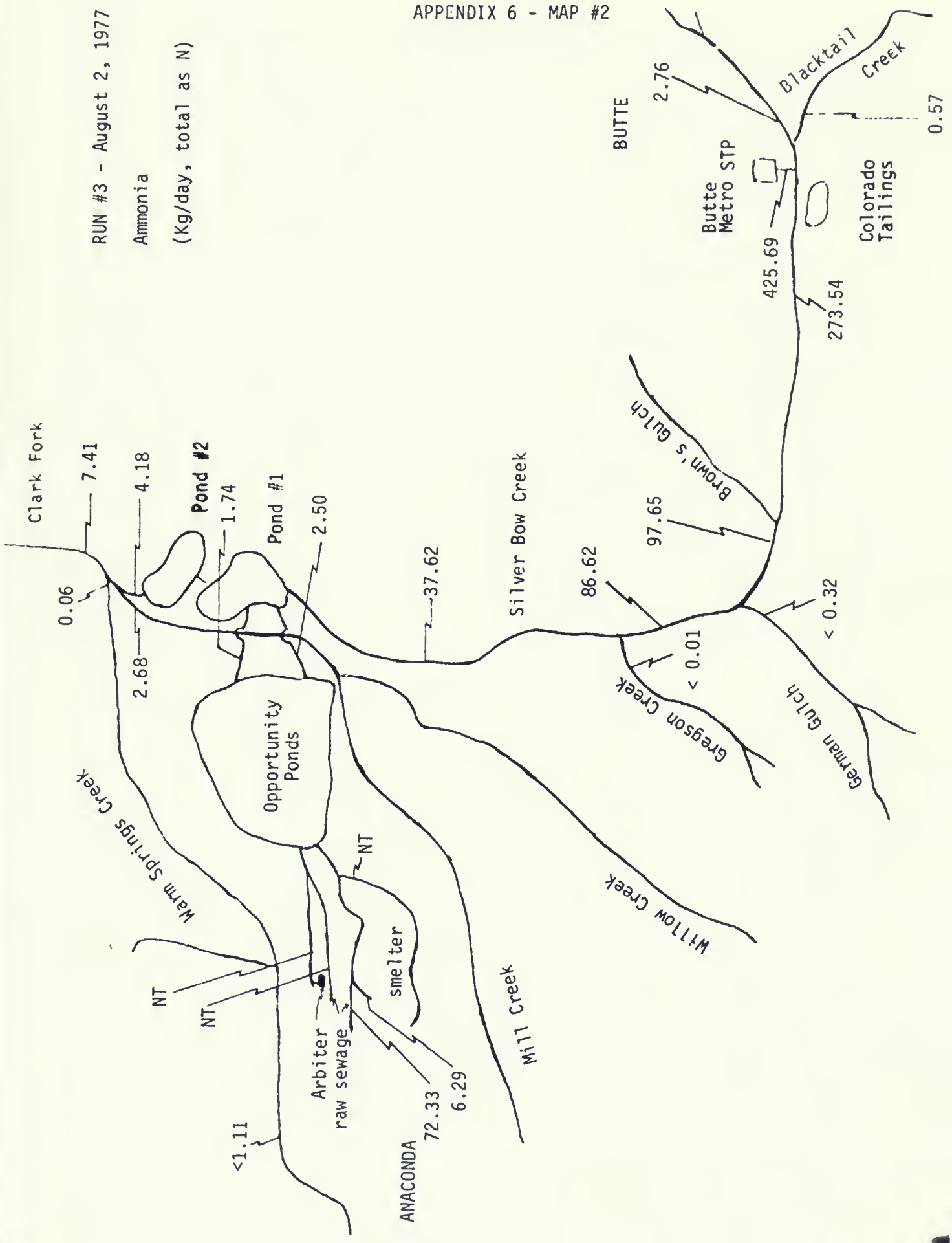
(Kg/day, total as N)



APPENDIX 6 - MAP #1



APPENDIX 6 - MAP #2

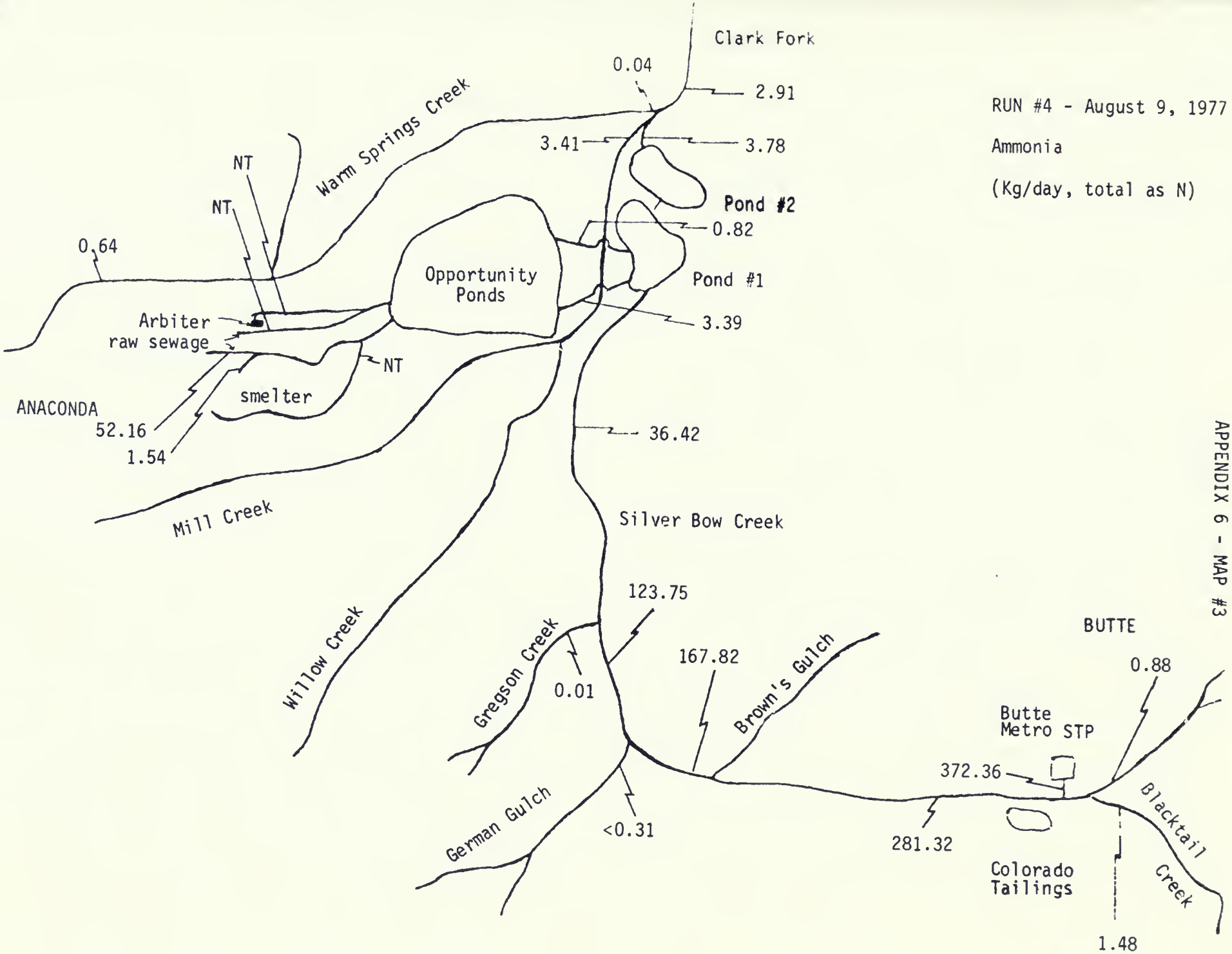


APPENDIX 6 - MAP #3

RUN #4 - August 9, 1977

Ammonia

(Kg/day, total as N)

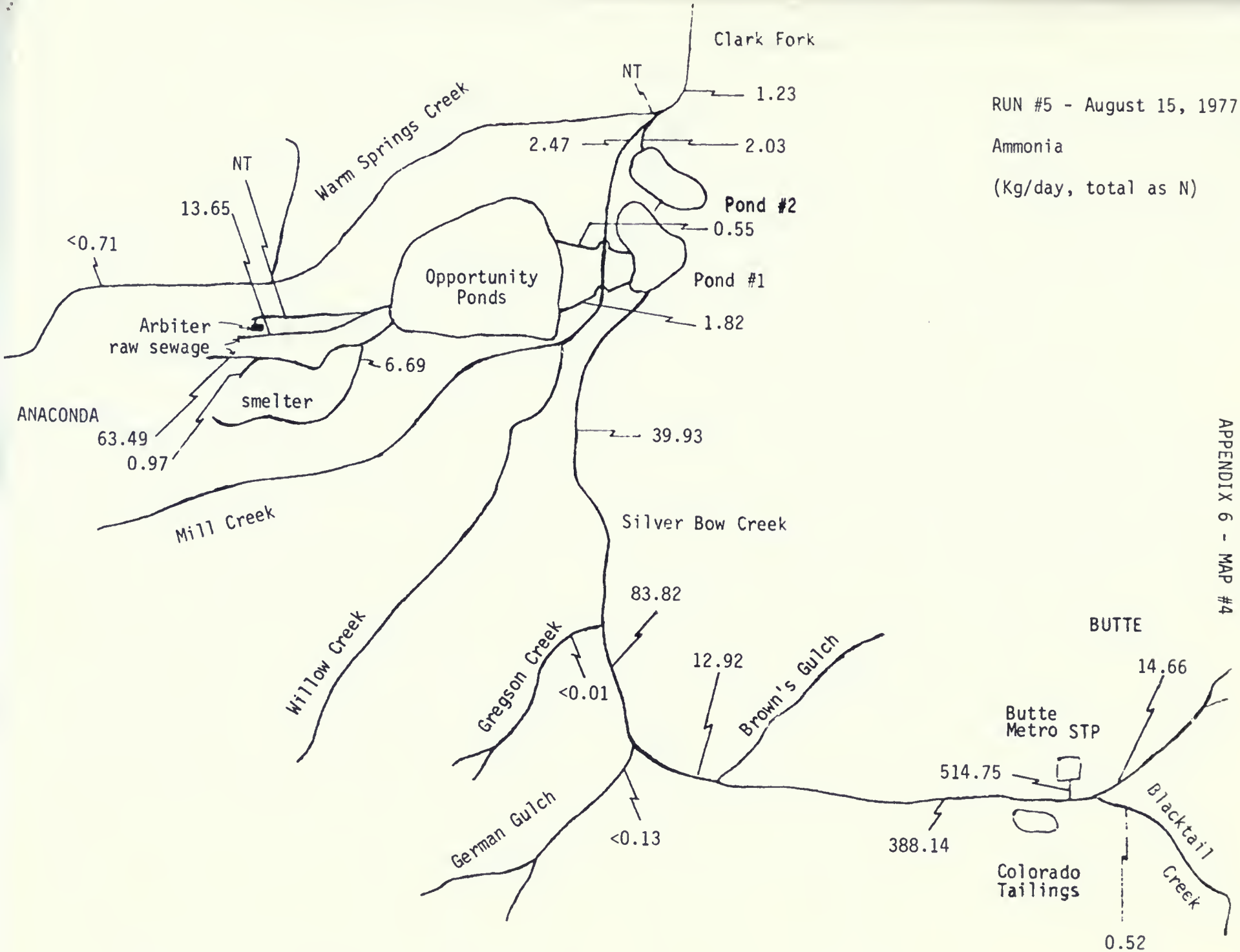


APPENDIX 6 - MAP #4

RUN #5 - August 15, 1977

Ammonia

(Kg/day, total as N)

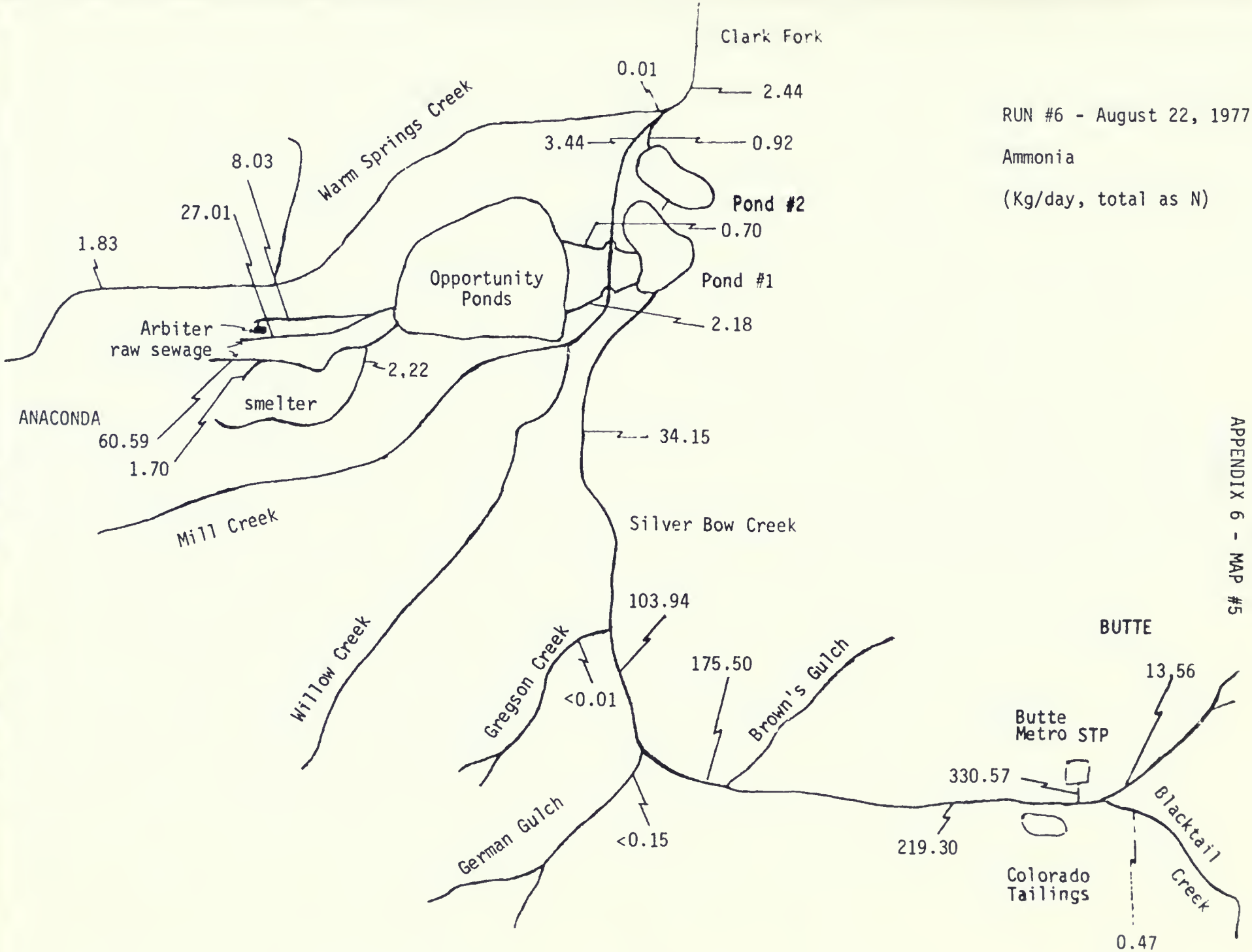


APPENDIX 6 - MAP #5

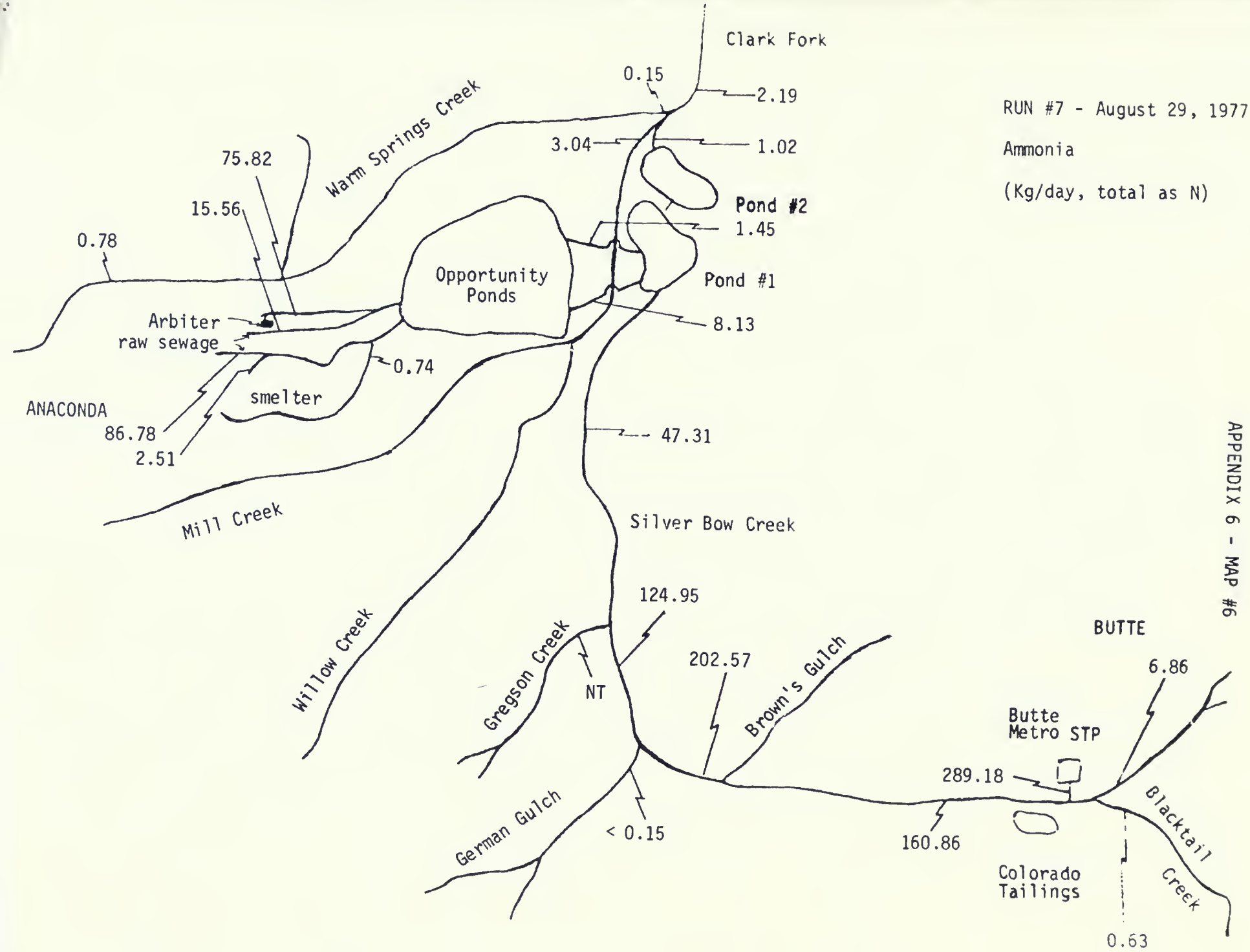
RUN #6 - August 22, 1977

Ammonia

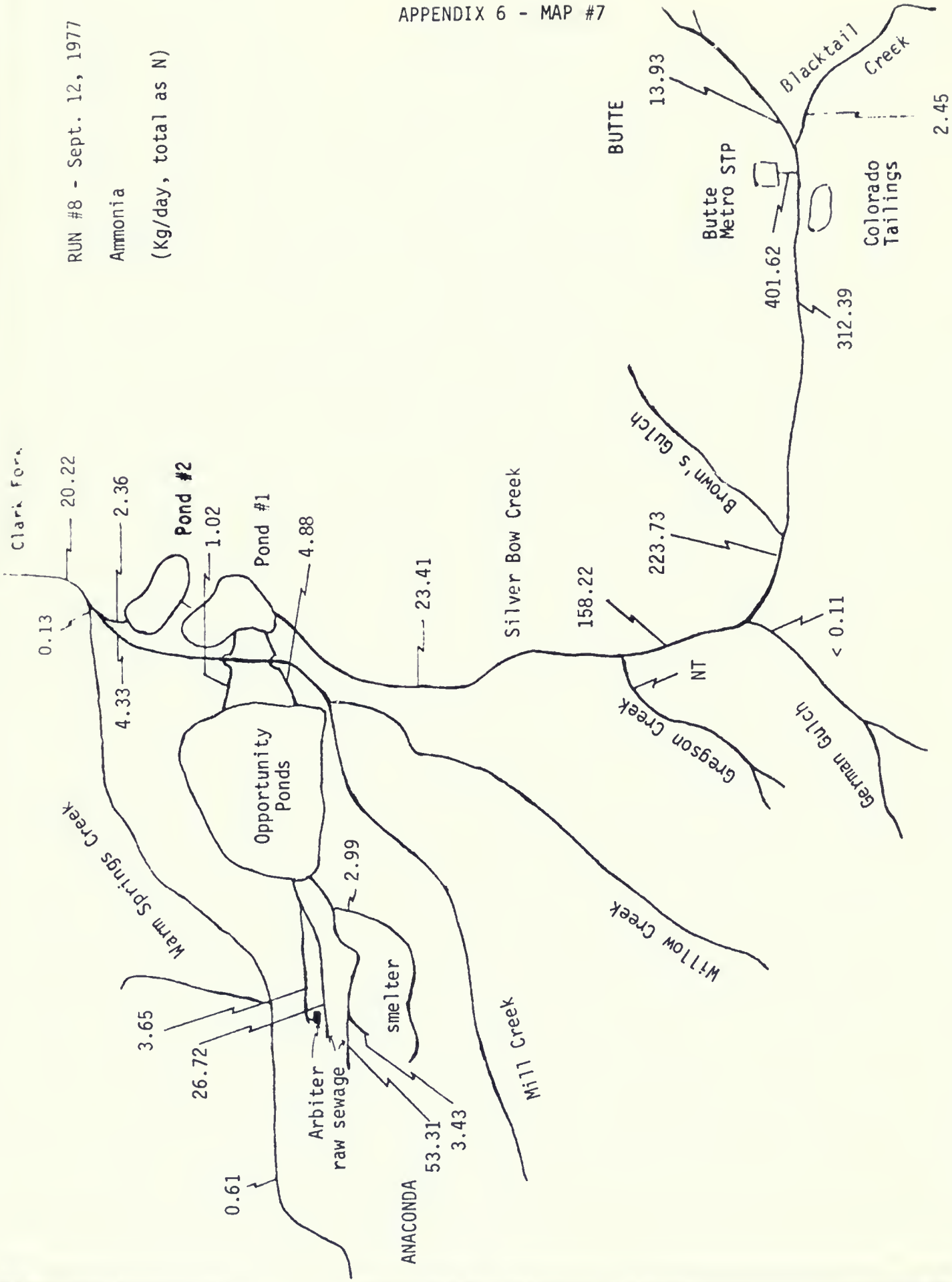
(Kg/day, total as N)



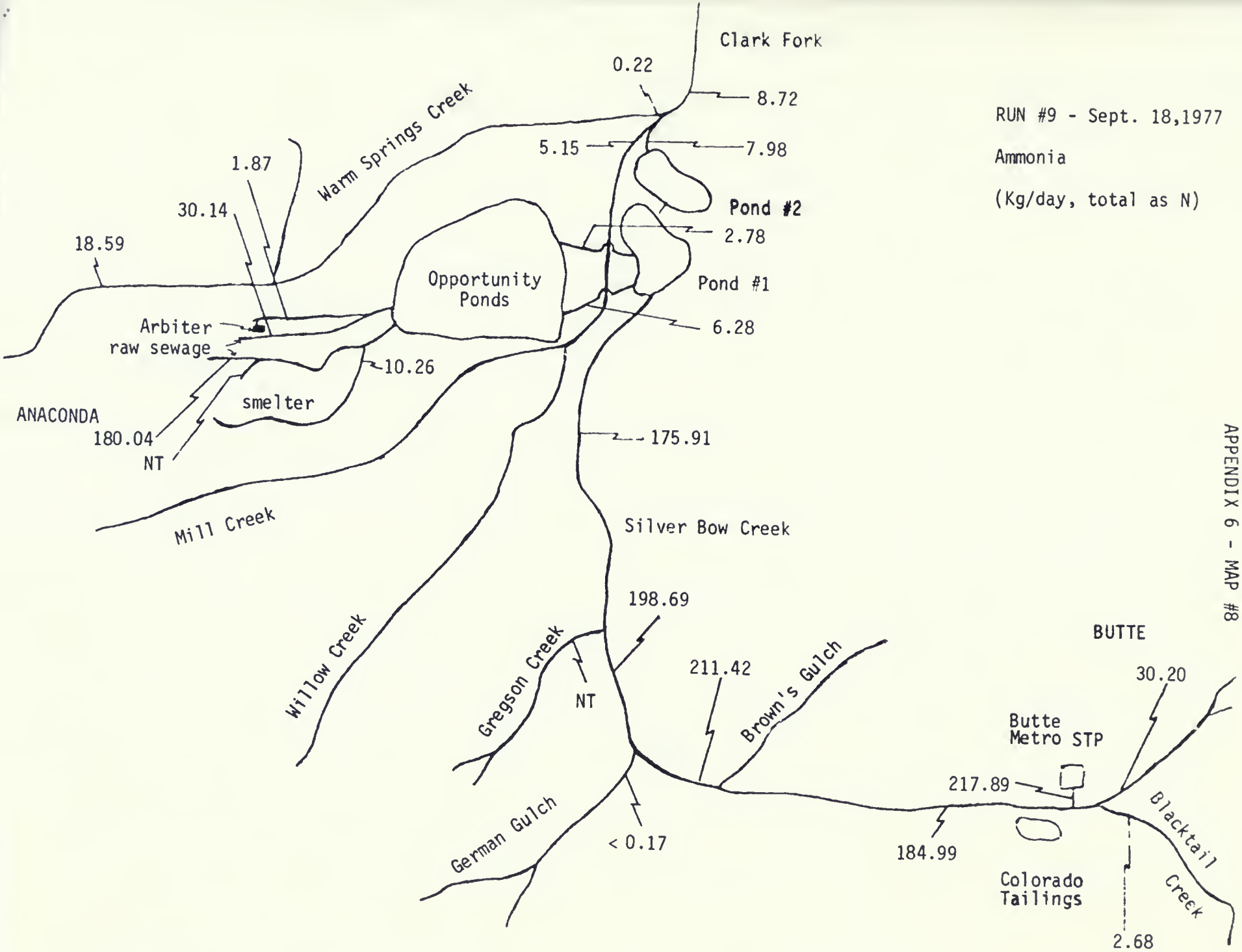
APPENDIX 6 - MAP #6



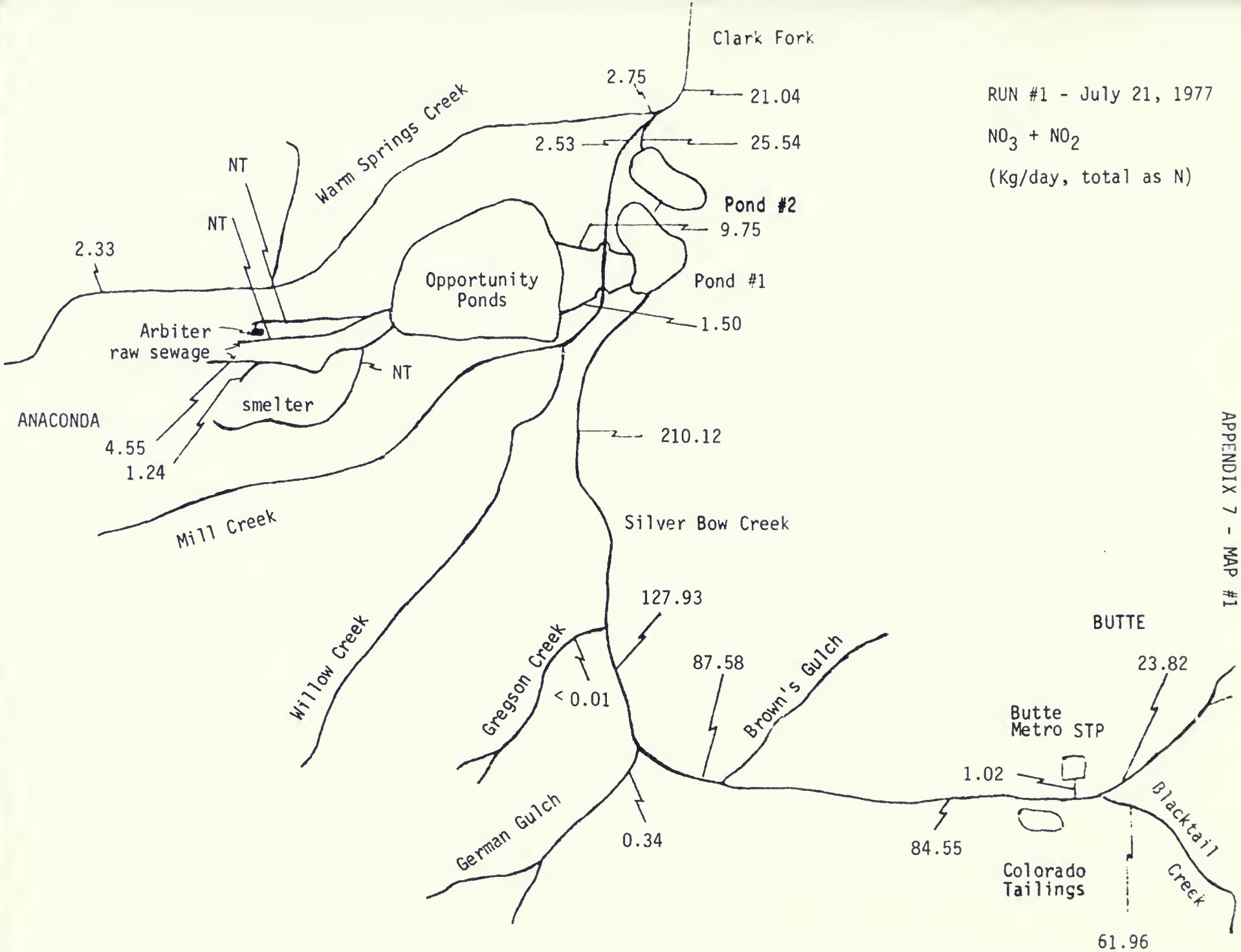
APPENDIX 6 - MAP #7



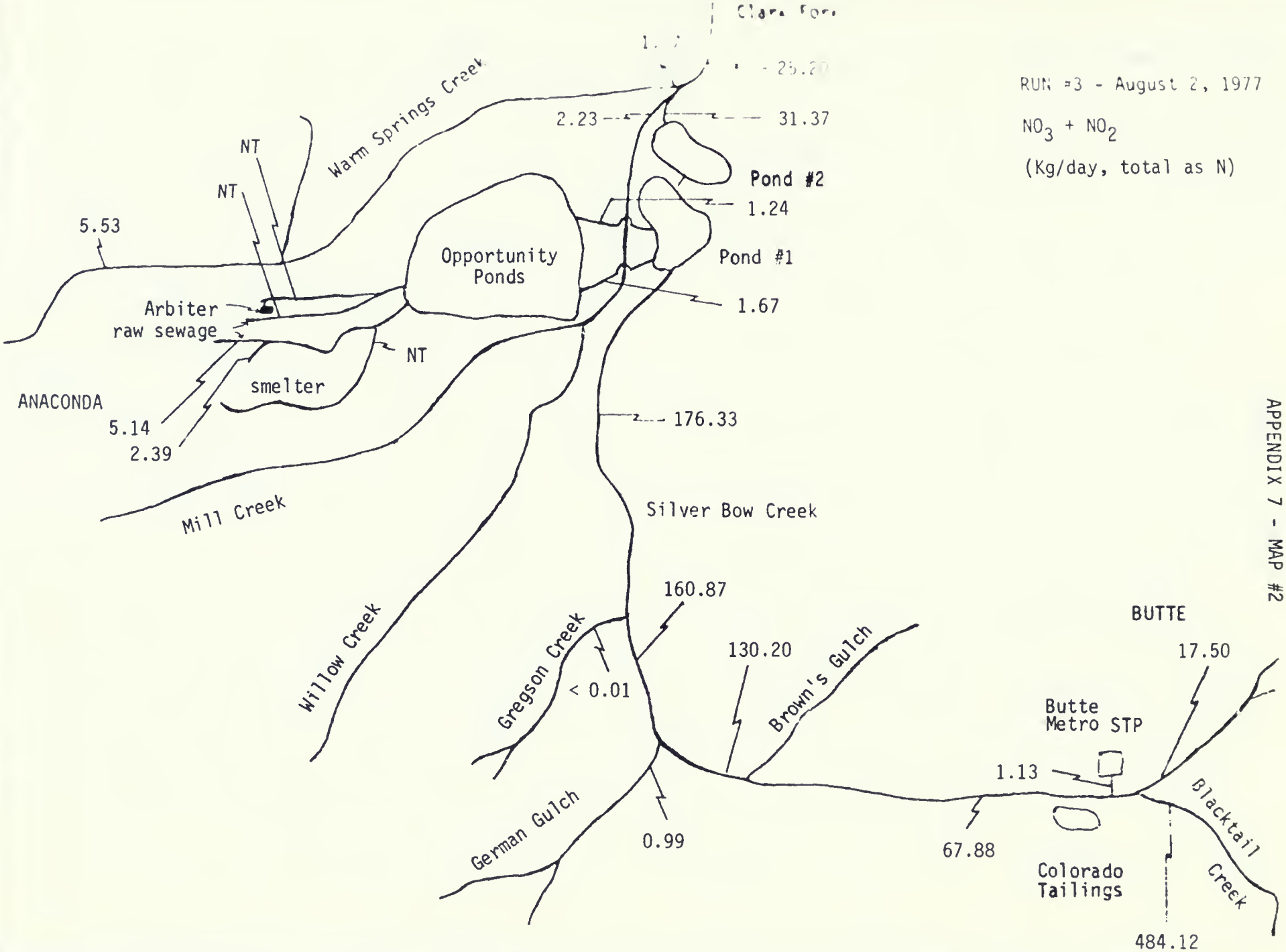
APPENDIX 6 - MAP #8



APPENDIX 7 - MAP #1



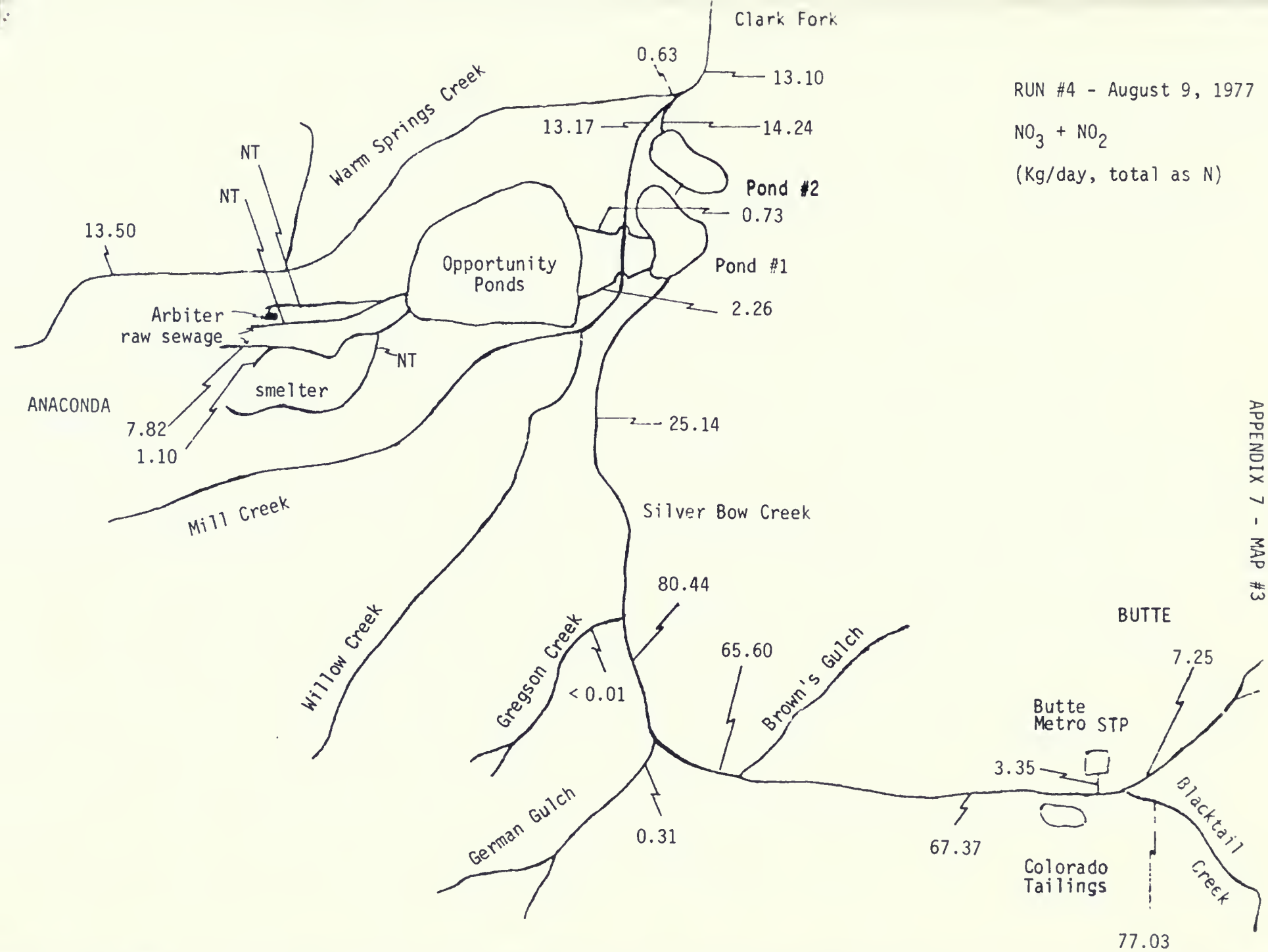
APPENDIX 7 - MAP #2



RUN #4 - August 9, 1977

$NO_3 + NO_2$

(Kg/day, total as N)

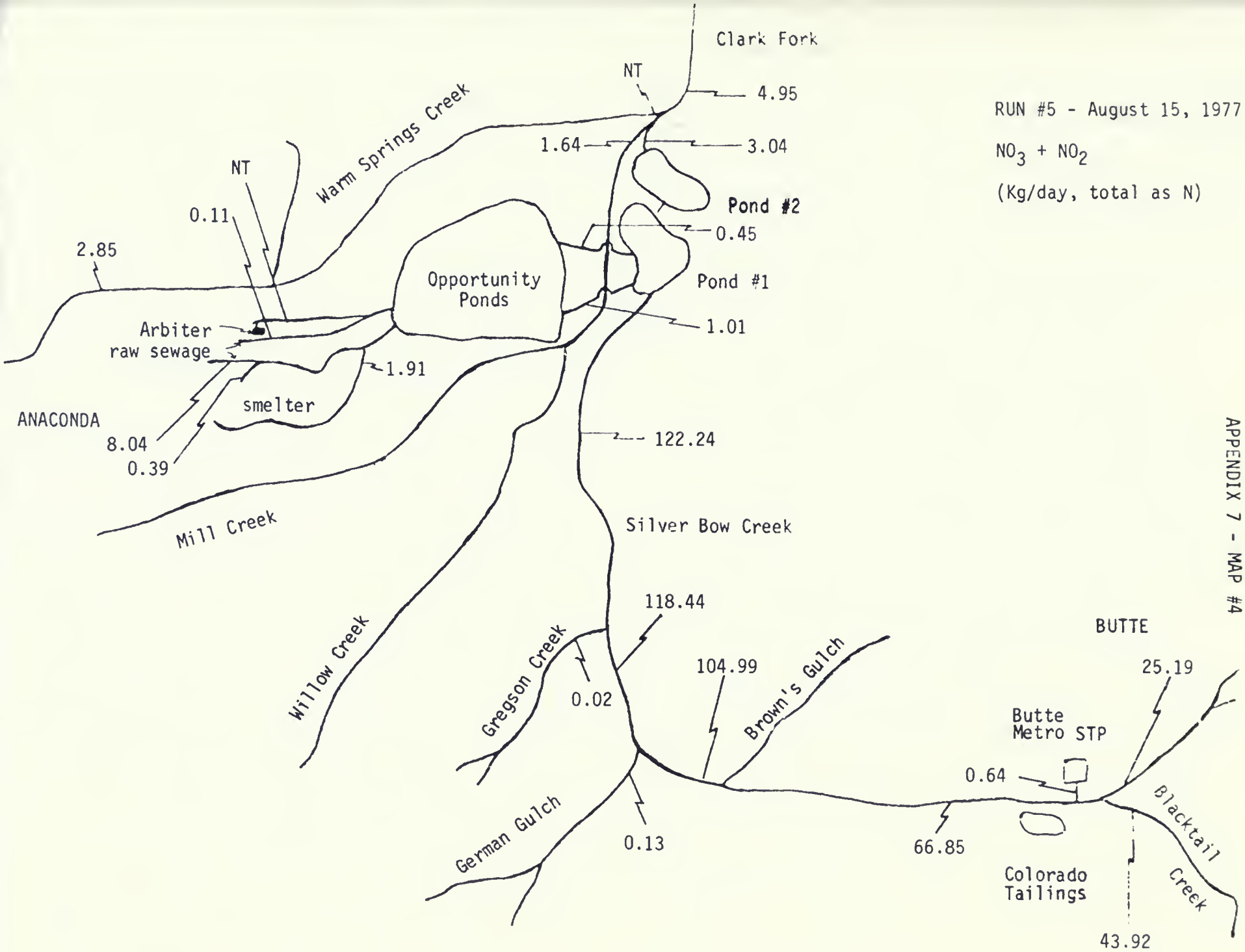


APPENDIX 7 - MAP #4

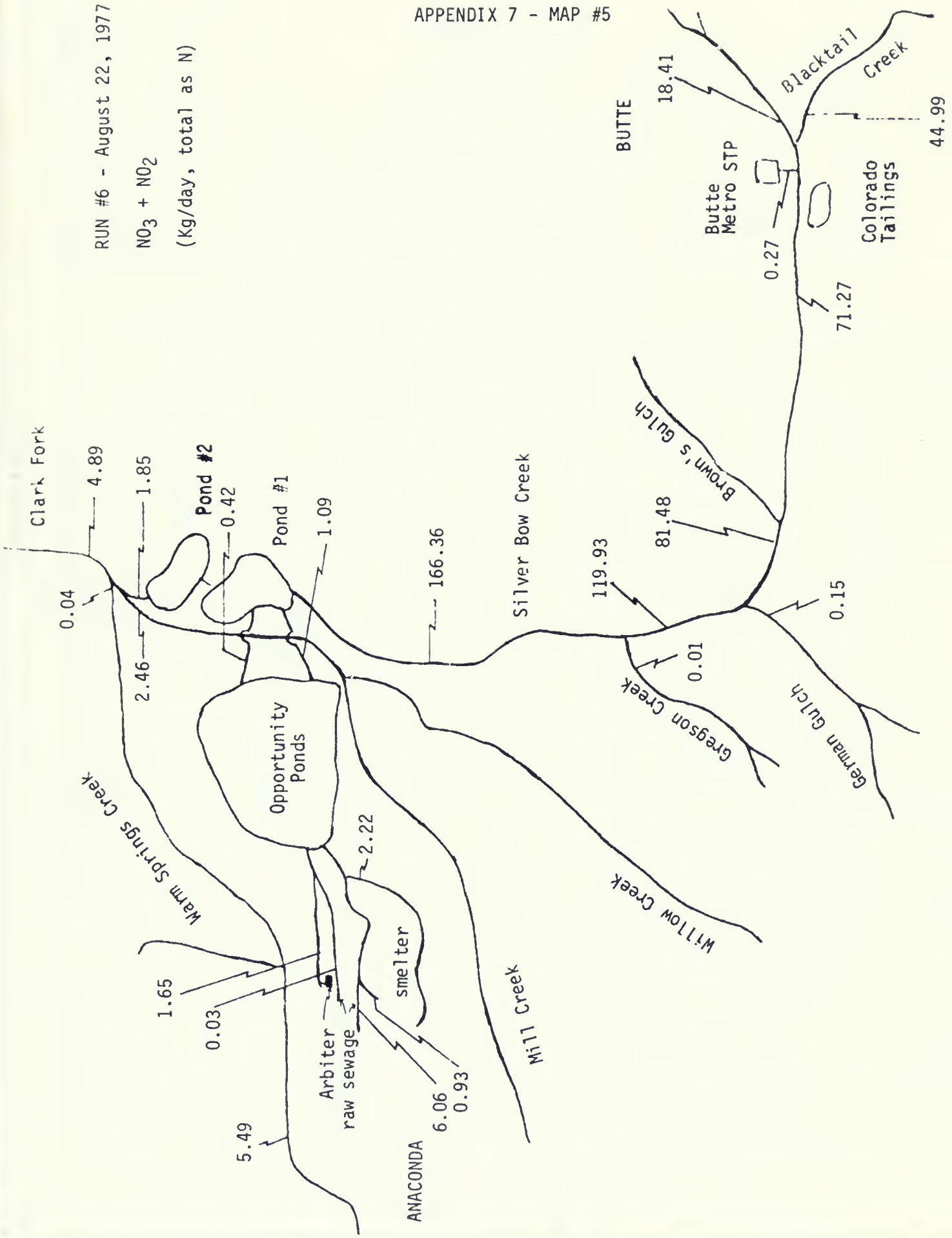
RUN #5 - August 15, 1977

$NO_3 + NO_2$

(Kg/day, total as N)



APPENDIX 7 - MAP #5

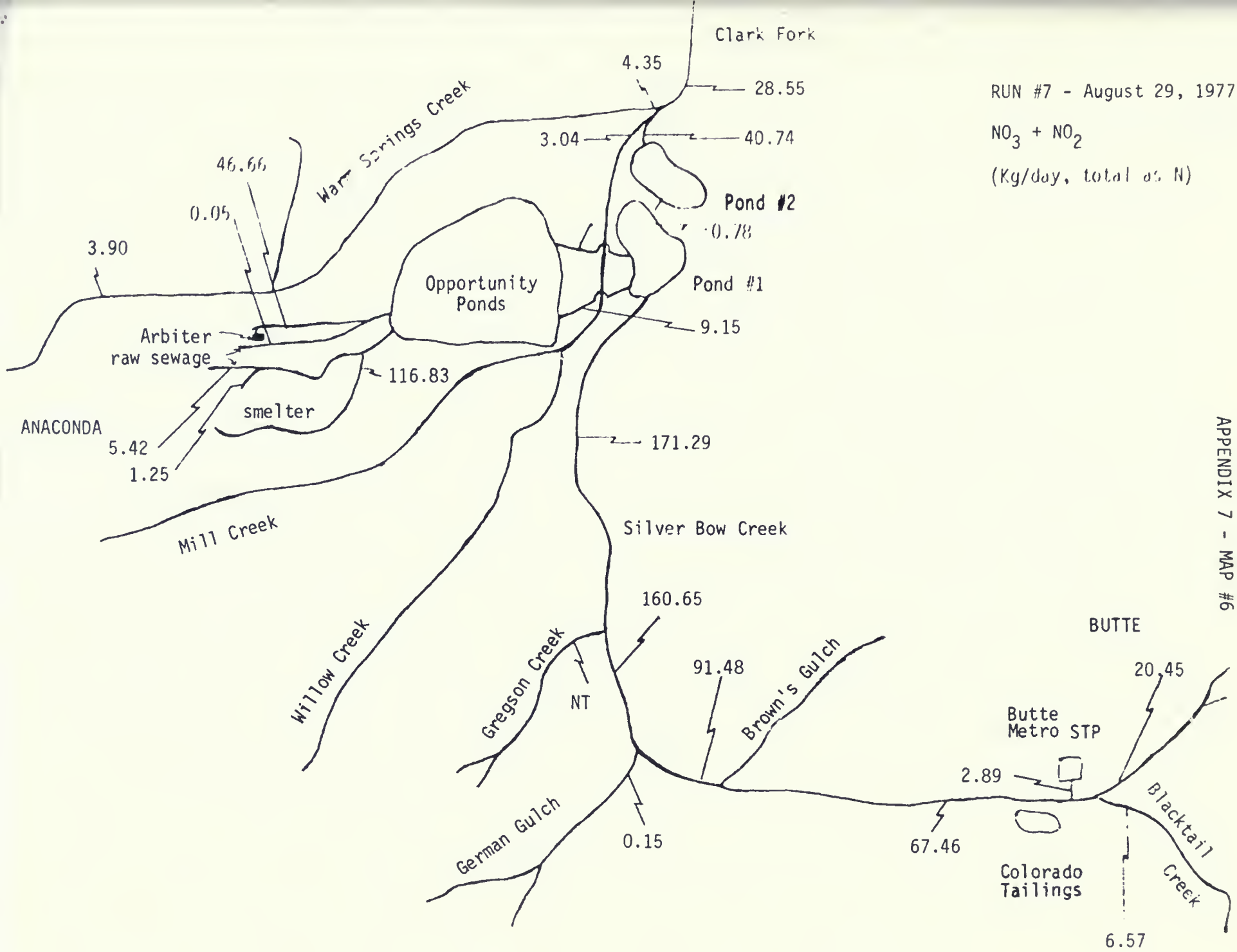


APPENDIX 7 - MAP #6

RUN #7 - August 29, 1977

$NO_3 + NO_2$

(Kg/day, total as N)

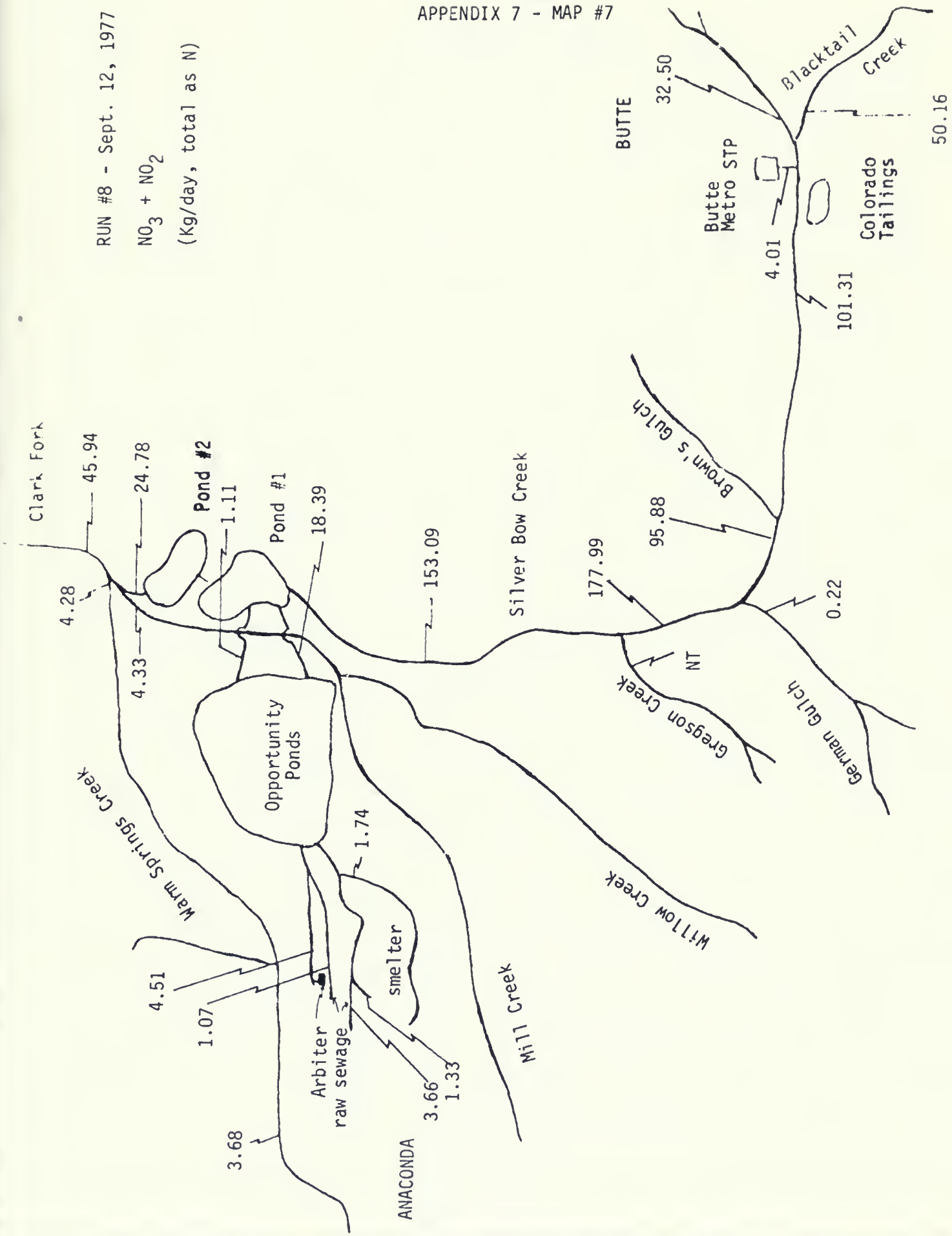


APPENDIX 7 - MAP #7

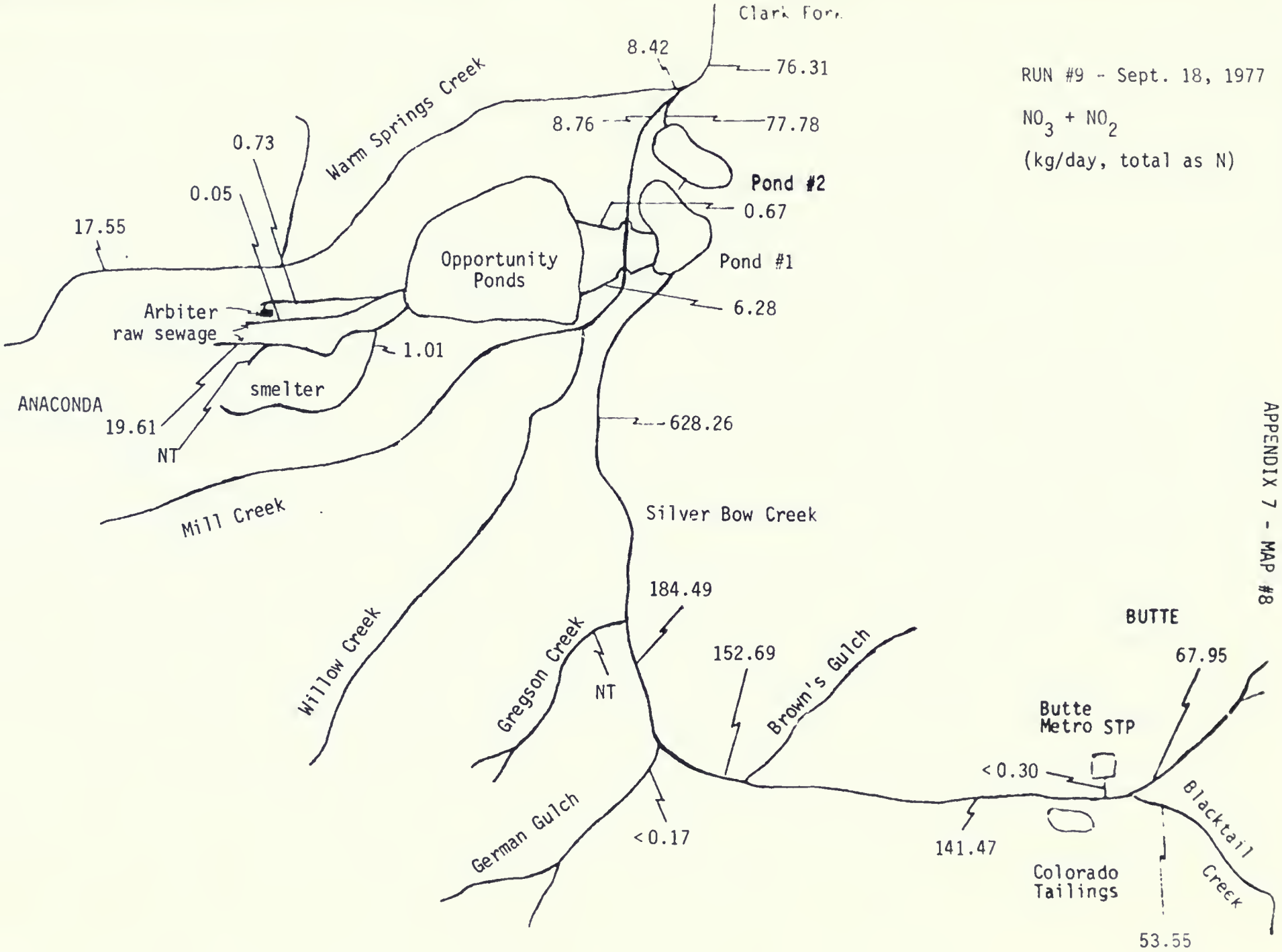
RUN #8 - Sept. 12, 1977

$NO_3 + NO_2$

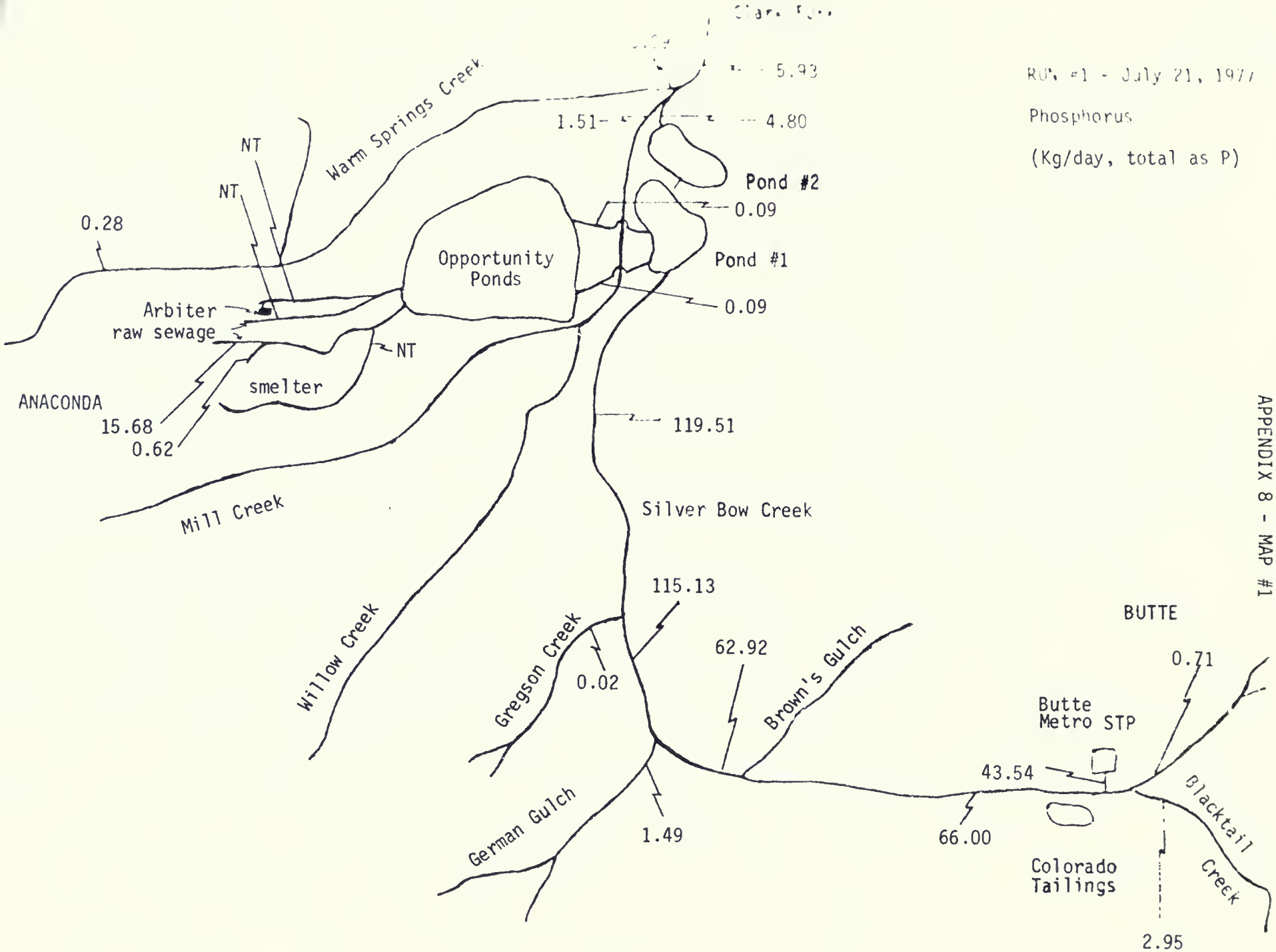
(Kg/day, total as N)



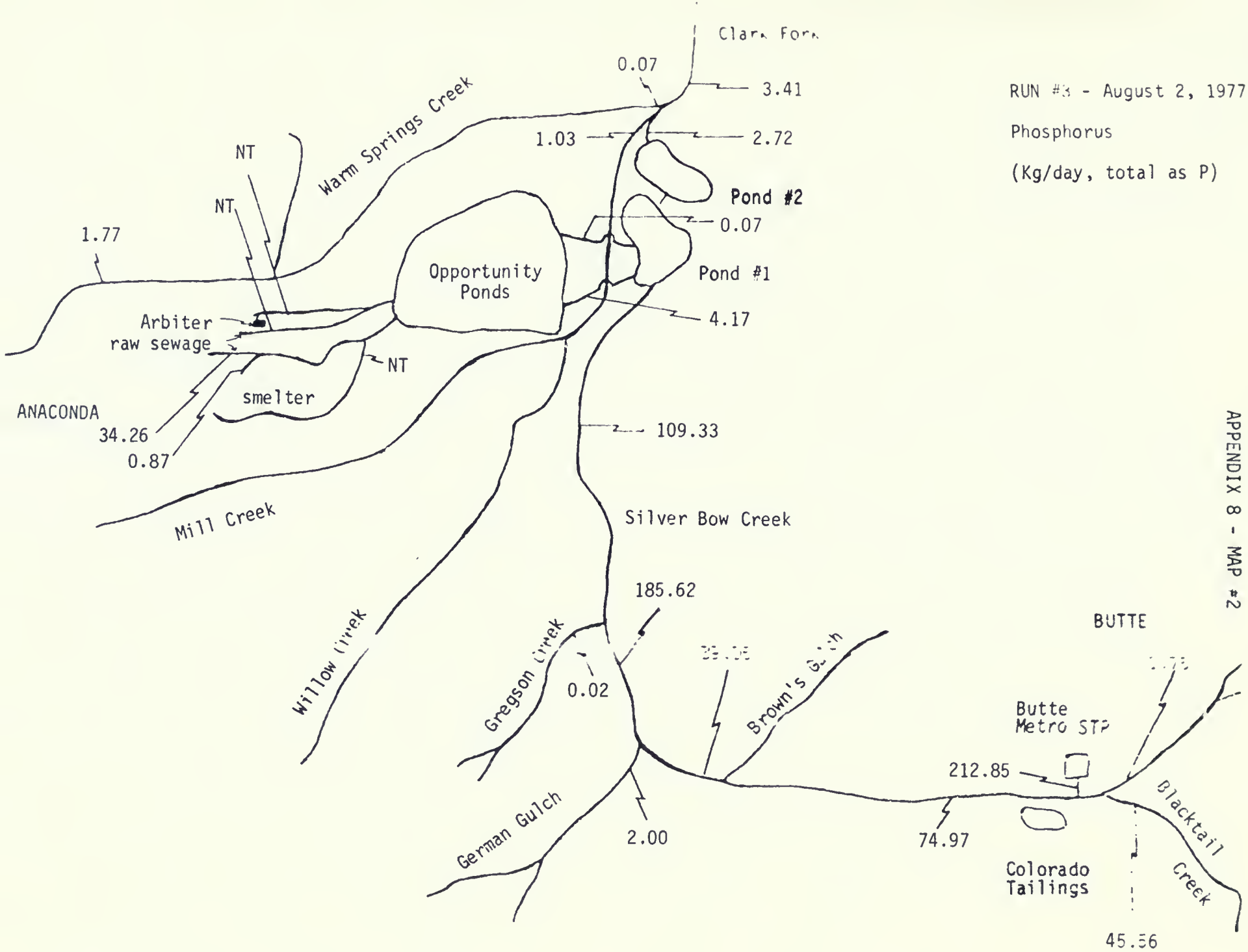
APPENDIX 7 - MAP #8



APPENDIX 8 - MAP #1



APPENDIX 8 - MAP #2

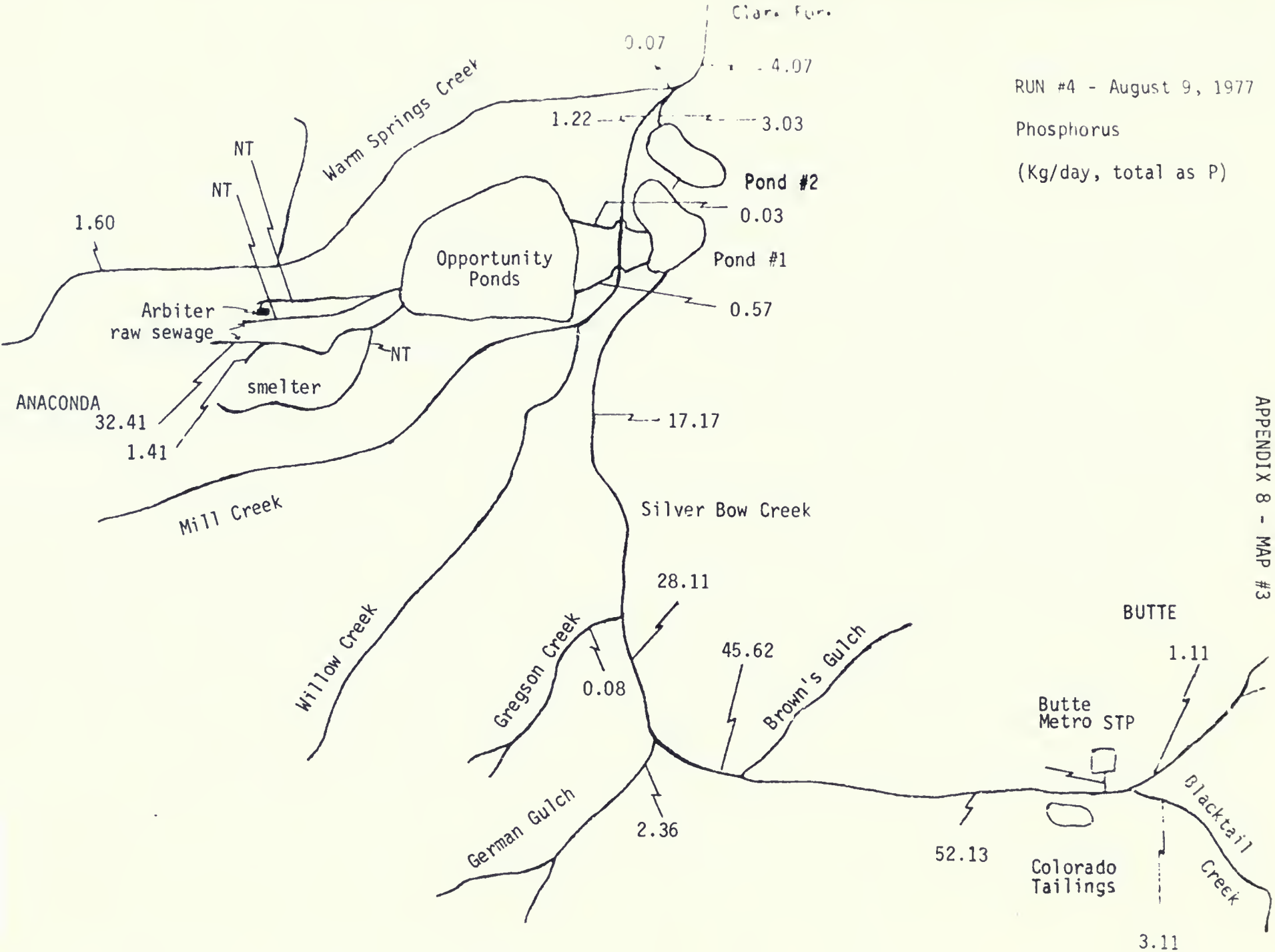


APPENDIX 8 - MAP #3

RUN #4 - August 9, 1977

Phosphorus

(Kg/day, total as P)

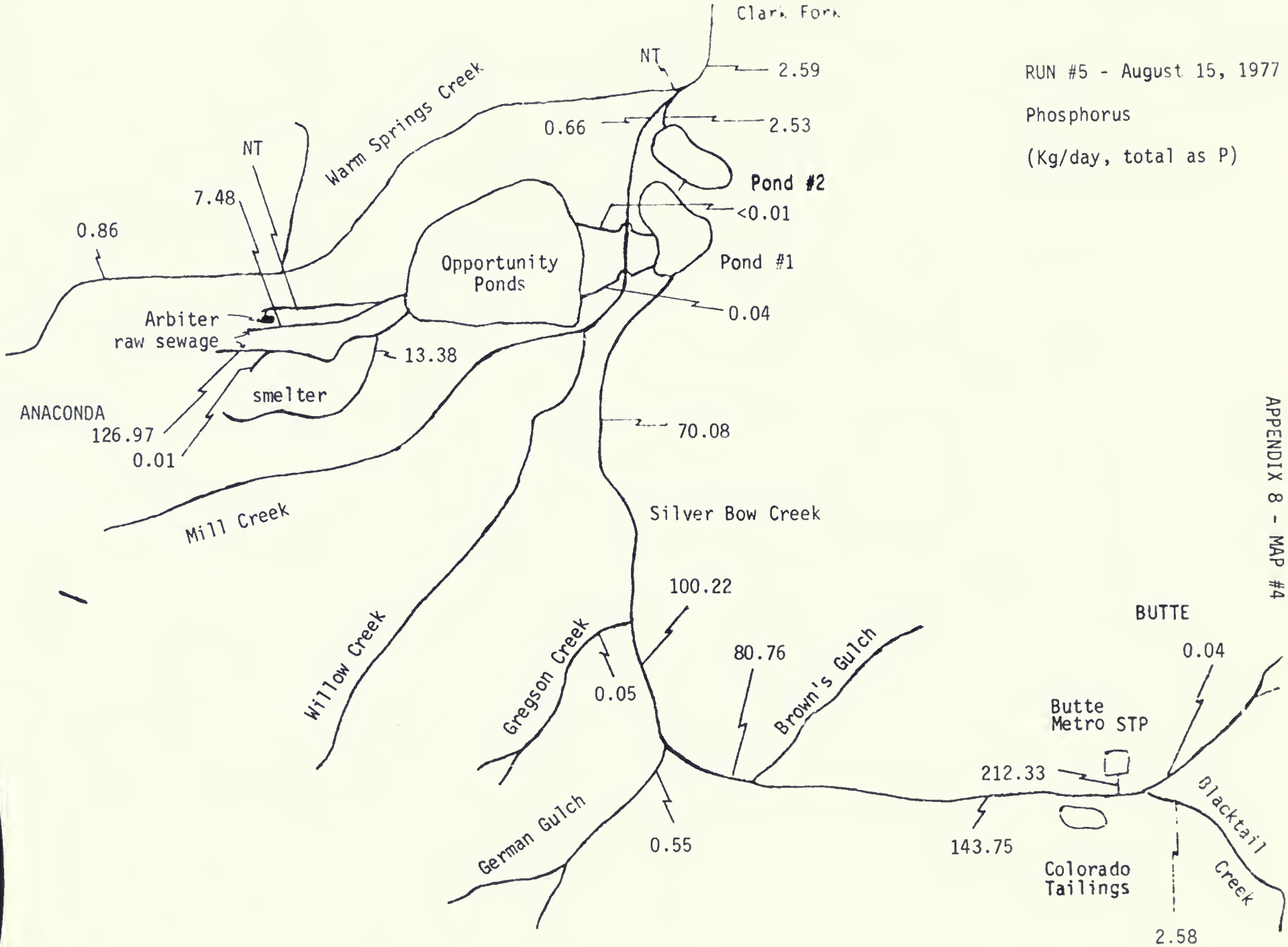


APPENDIX 8 - MAP #4

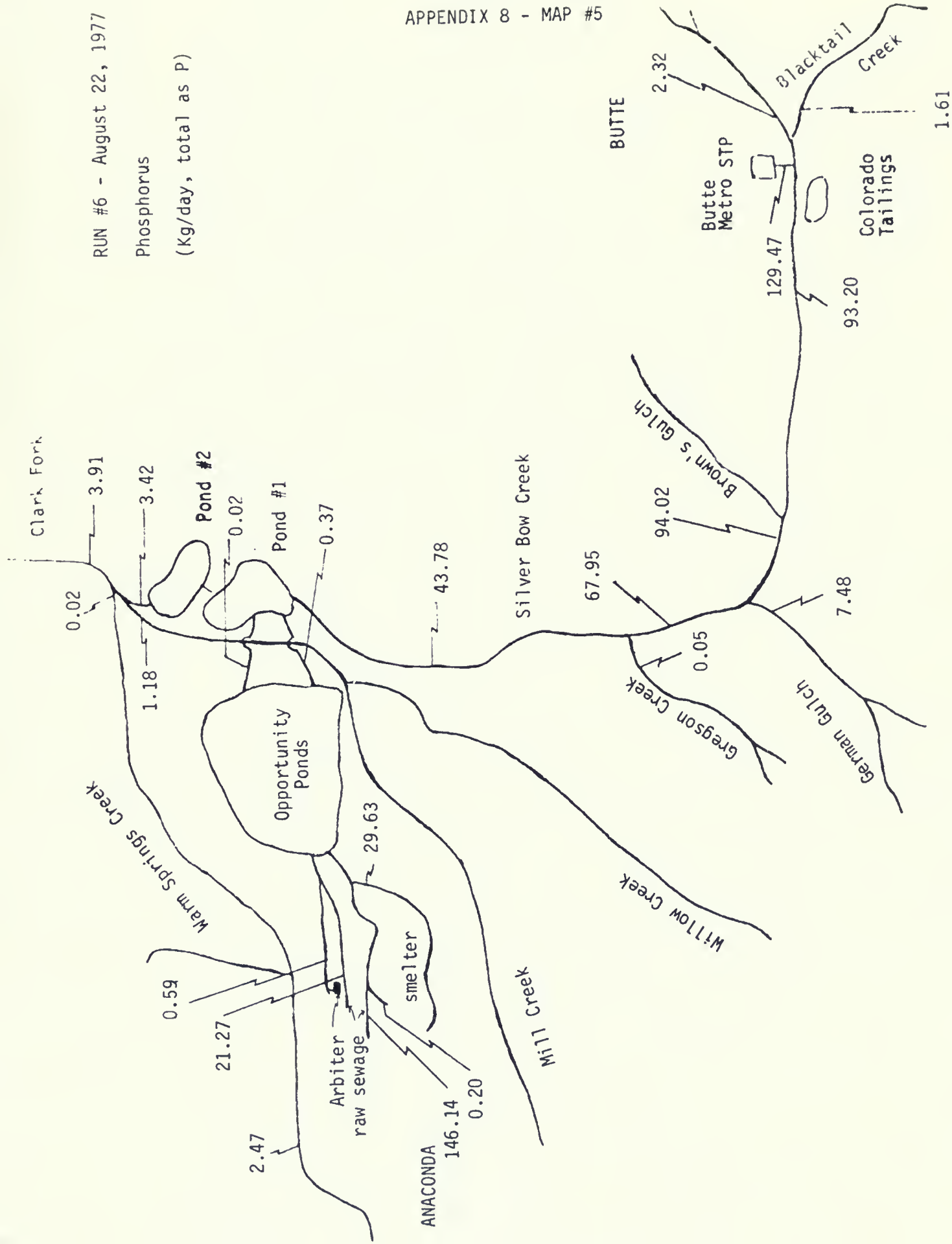
RUN #5 - August 15, 1977

Phosphorus

(Kg/day, total as P)



APPENDIX 8 - MAP #5

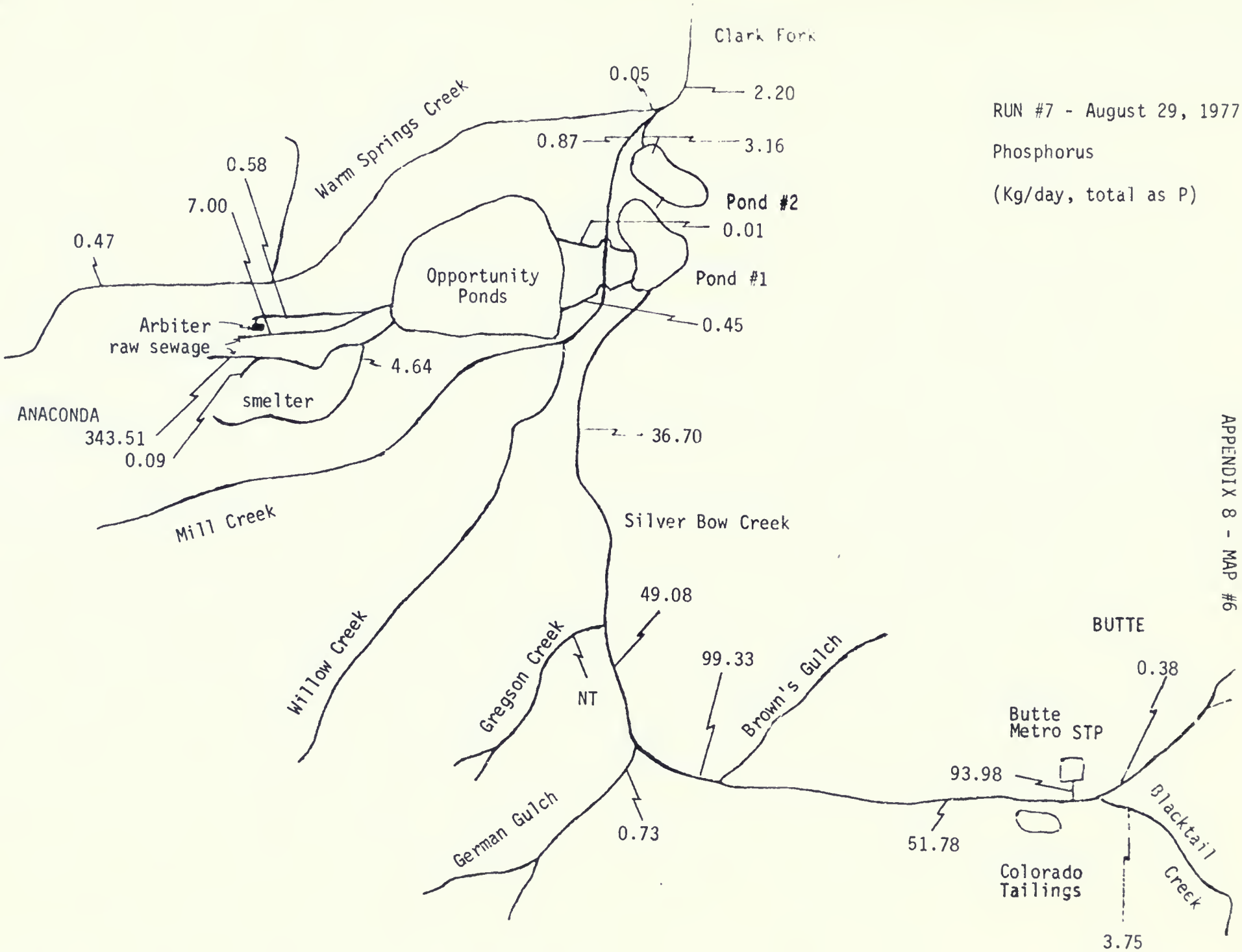


APPENDIX 8 - MAP #6

RUN #7 - August 29, 1977

Phosphorus

(Kg/day, total as P)

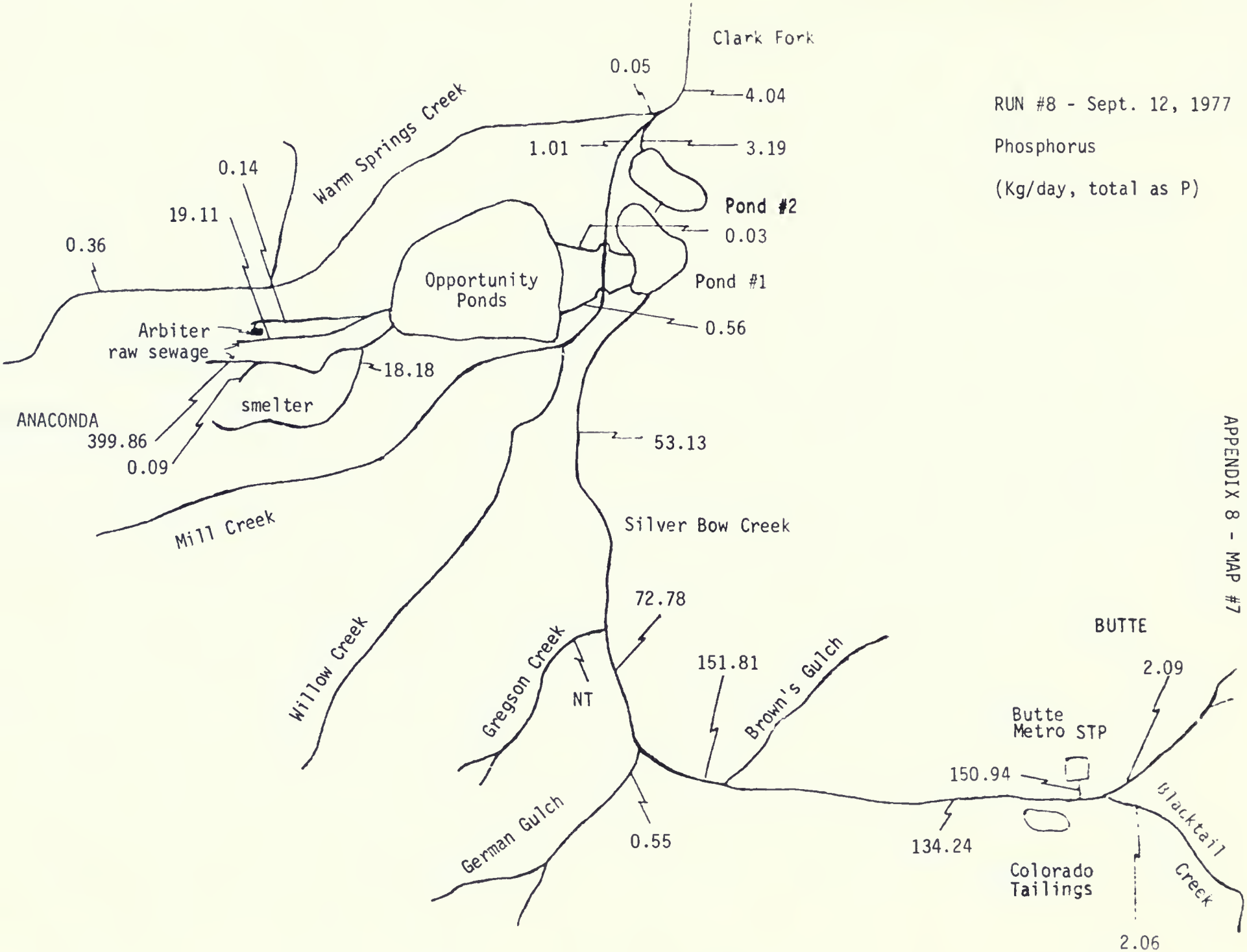


APPENDIX 8 - MAP #7

RUN #8 - Sept. 12, 1977

Phosphorus

(Kg/day, total as P)

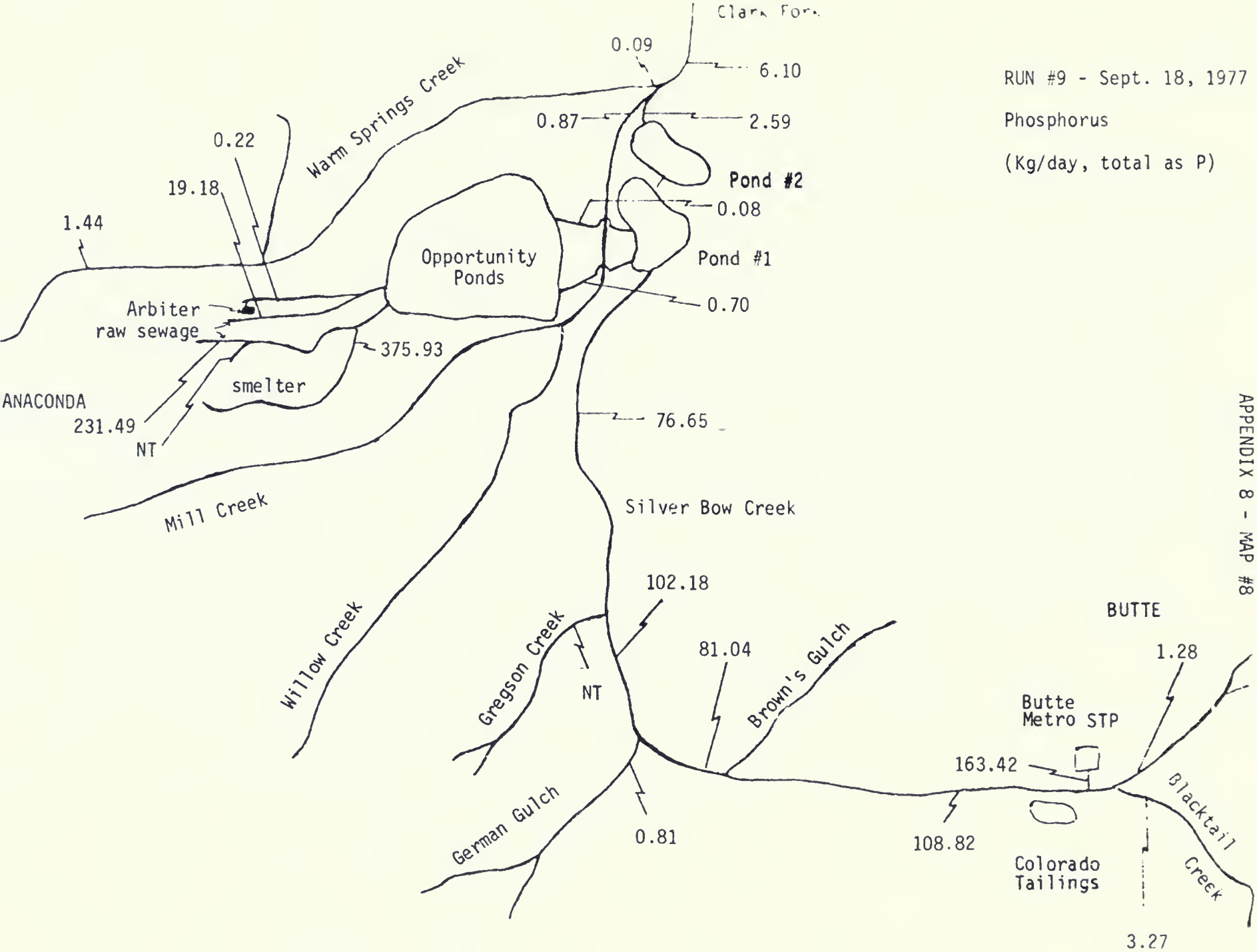


APPENDIX 8 - MAP #8

RUN #9 - Sept. 18, 1977

Phosphorus

(Kg/day, total as P)

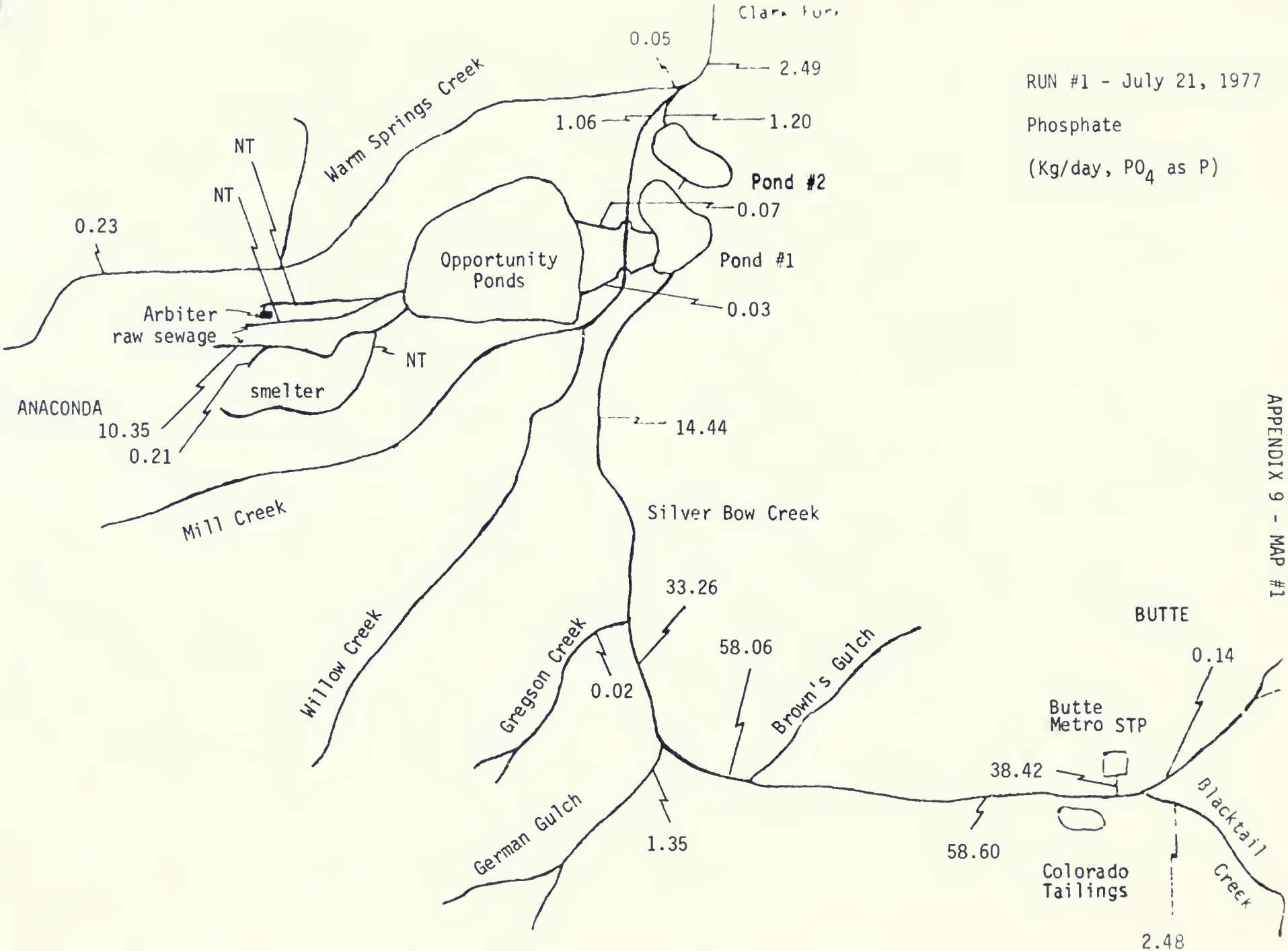


APPENDIX 9 - MAP #1

RUN #1 - July 21, 1977

Phosphate

(Kg/day, PO_4 as P)

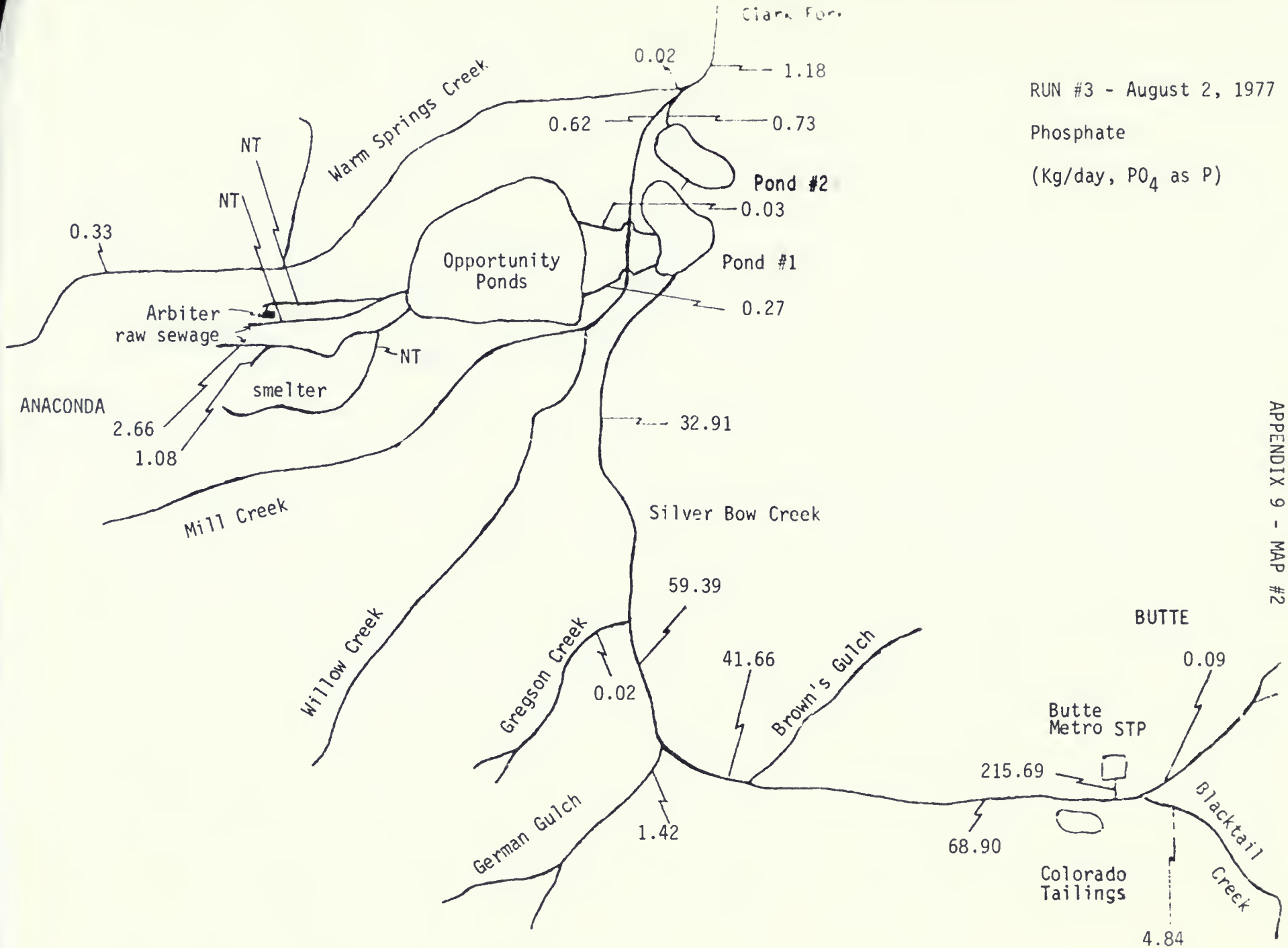


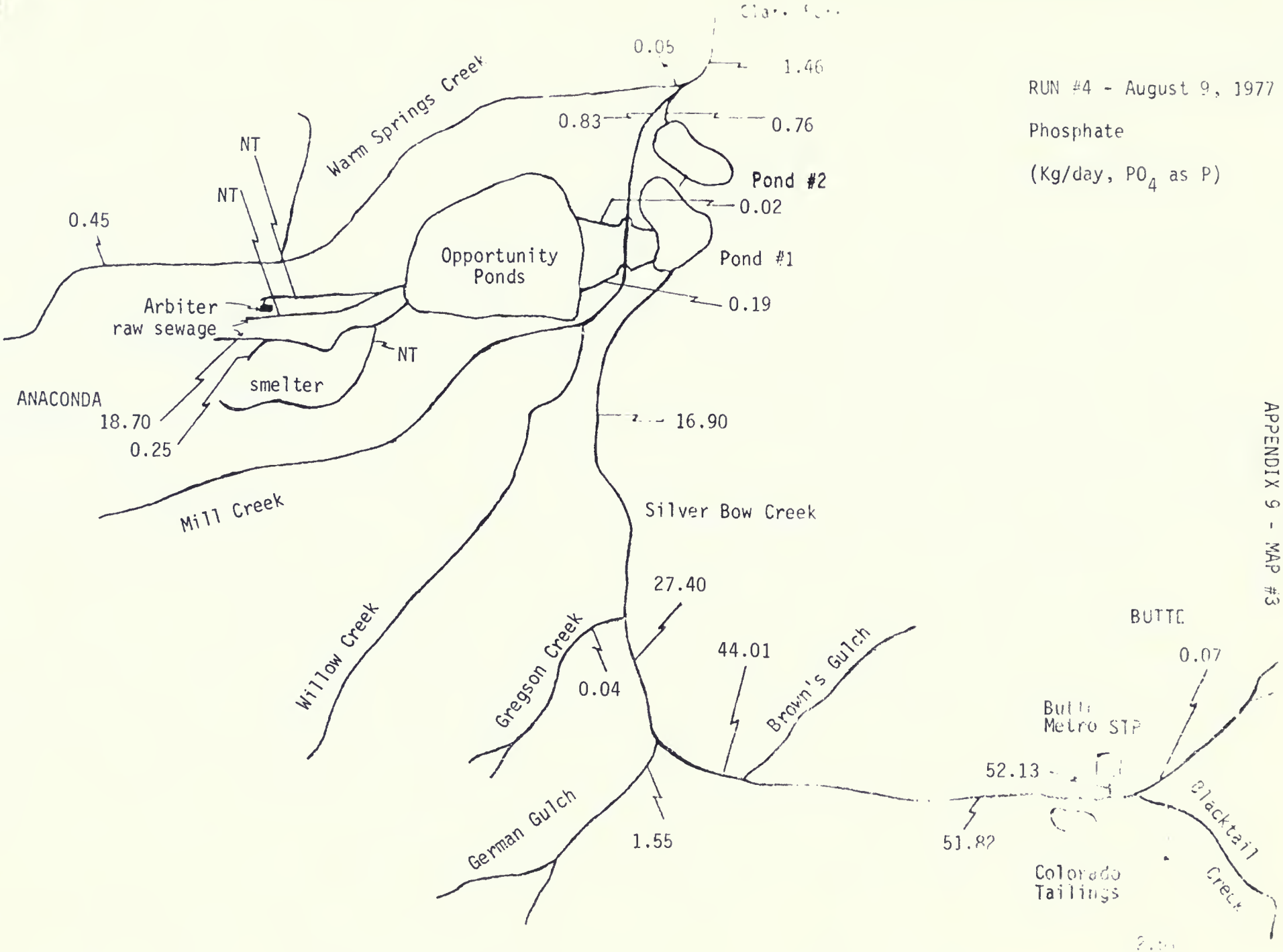
APPENDIX 9 - MAP #2

RUN #3 - August 2, 1977

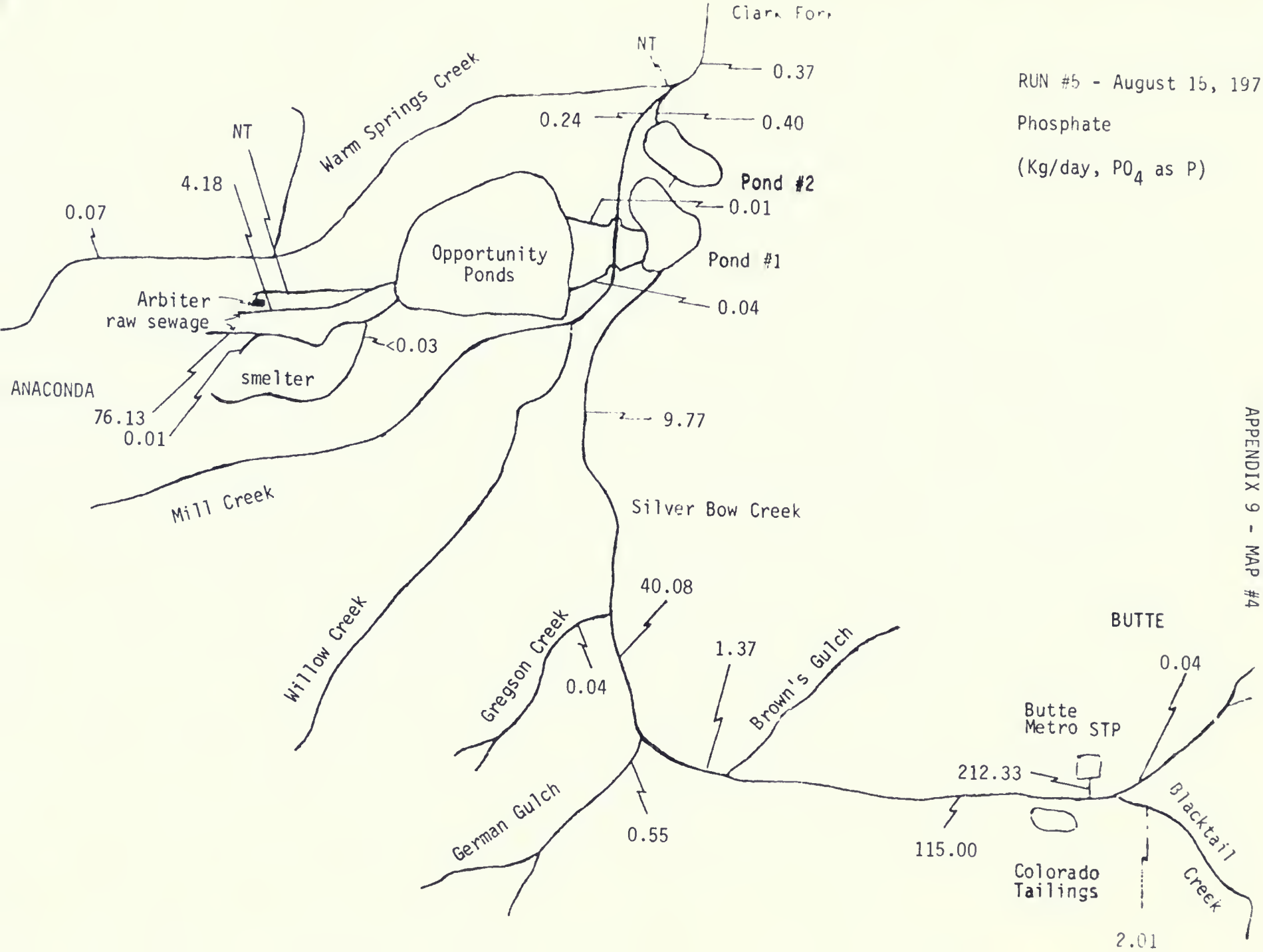
Phosphate

(Kg/day, PO_4 as P)





APPENDIX 9 - MAP #3

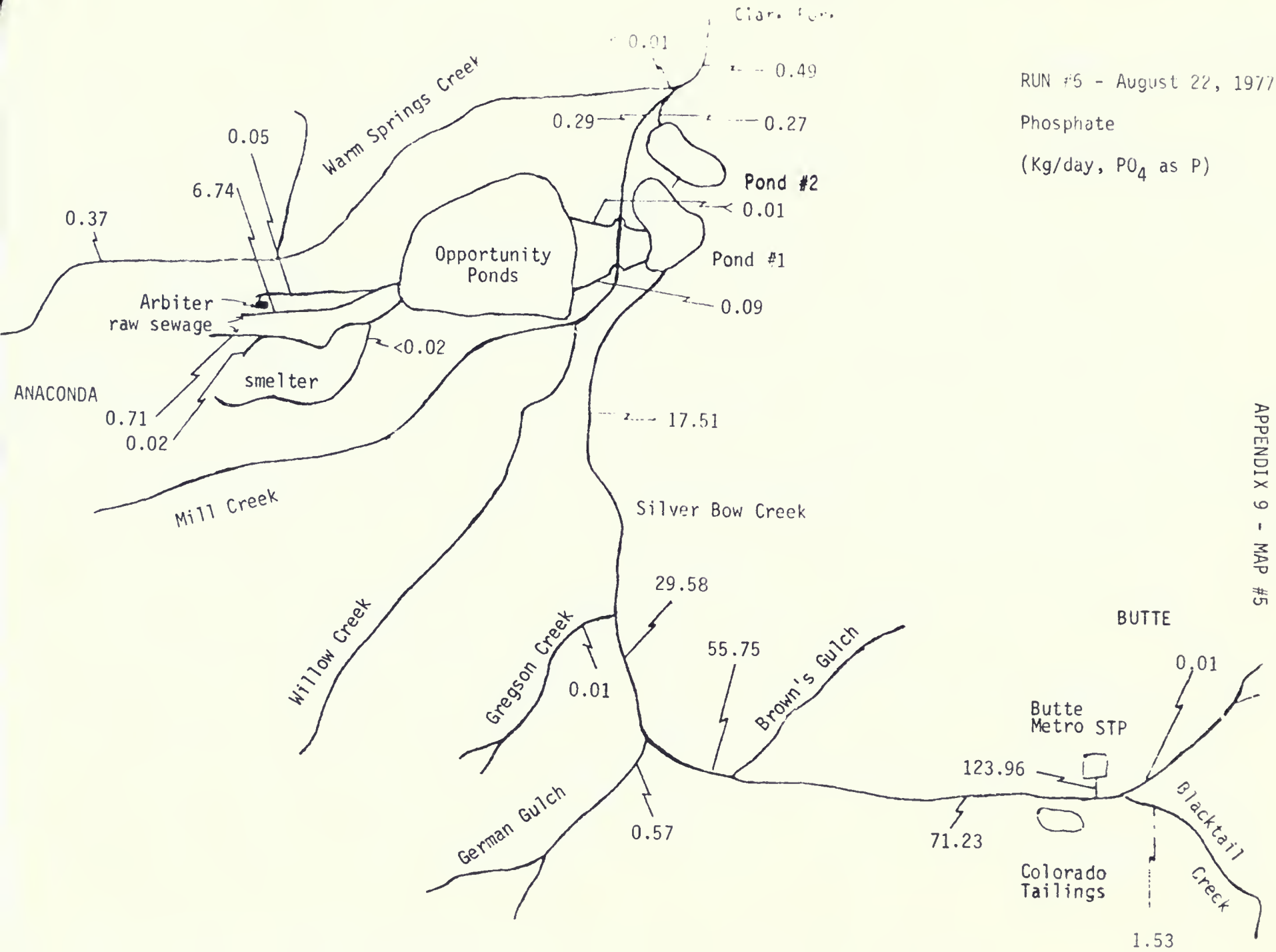

RUN #5 - August 15, 1977
Phosphate
(Kg/day, PO_4 as P)
Clark Fork
NT
0.37
0.24
0.40
Pond #2
0.01
Pond #1
0.04
Warm Springs Creek
NT
4.18
0.07
Opportunity Ponds
Arbiter
raw sewage
<0.03
smelter
ANACONDA
76.13
0.01
Mill Creek
9.77
Silver Bow Creek
40.08
Willow Creek
Gregson Creek
0.04
1.37
Brown's Gulch
German Gulch
0.55
BUTTE
0.04
Butte Metro STP
212.33
115.00
Colorado Tailings
Blacktail Creek
2.01

APPENDIX 9 - MAP #5

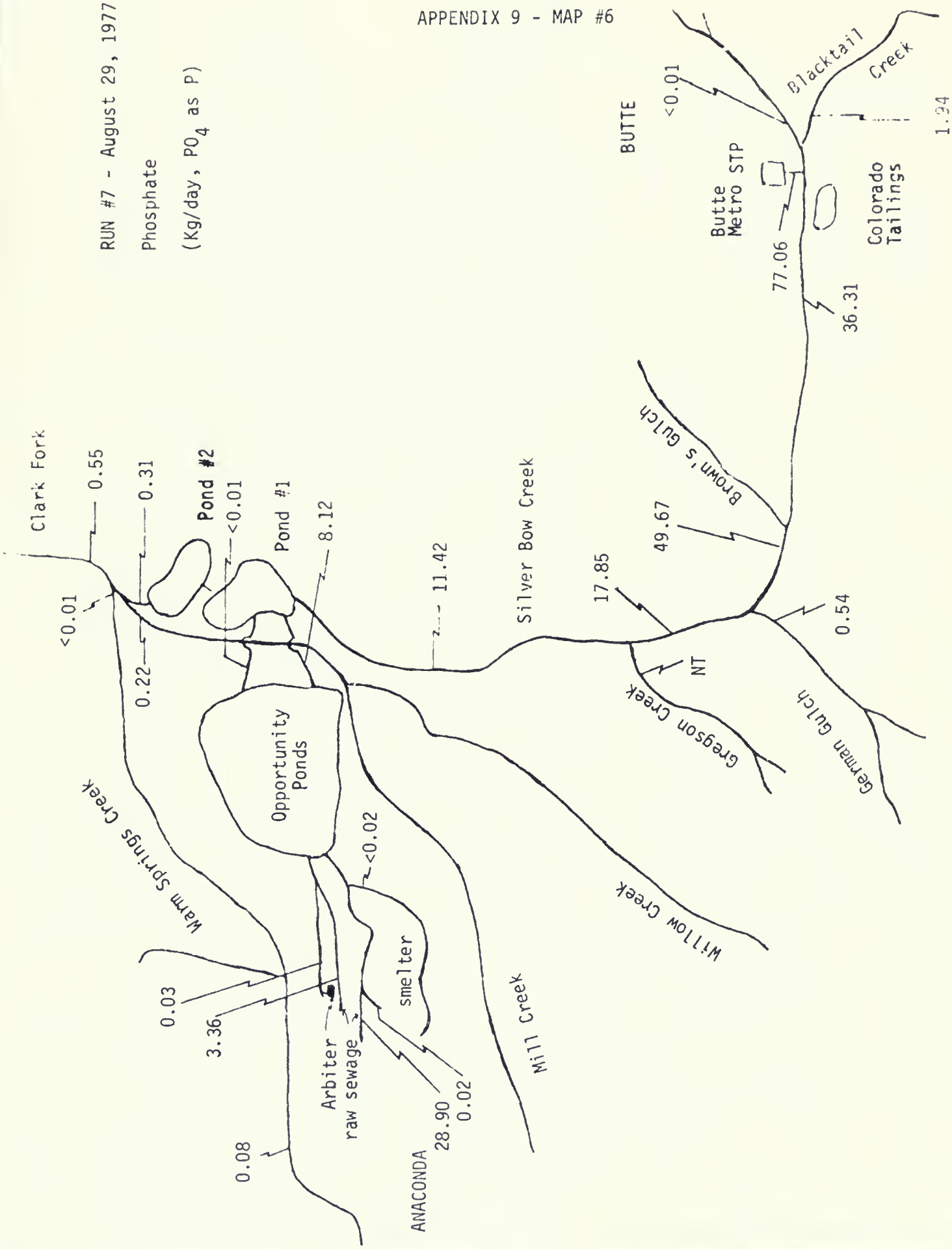
RUN #5 - August 22, 1977

Phosphate

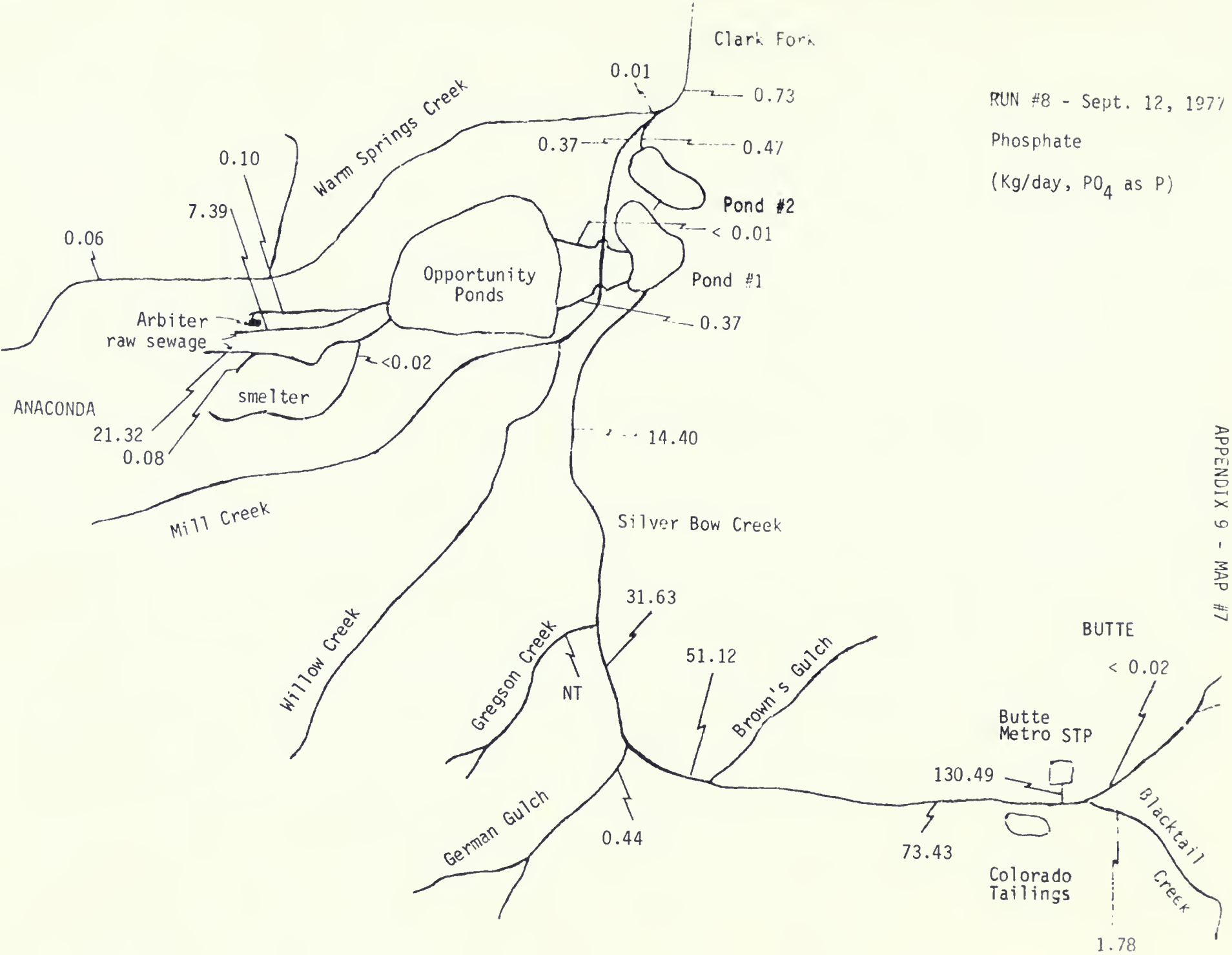
(Kg/day, PO_4 as P)



APPENDIX 9 - MAP #6



APPENDIX 9 - MAP #7

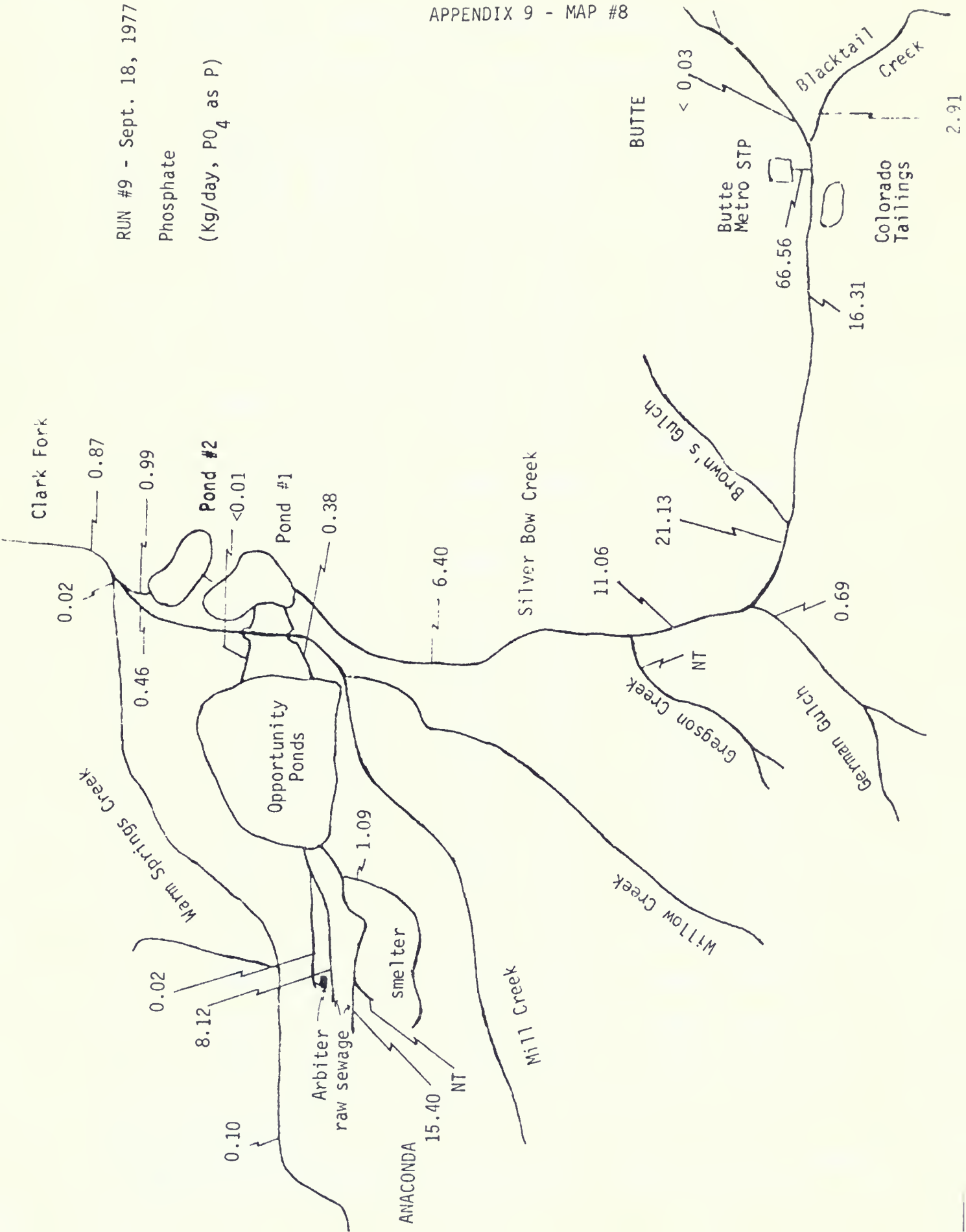


APPENDIX 9 - MAP #8

RUN #9 - Sept. 18, 1977

Phosphate

(Kg/day, PO_4 as P)



APPENDIX 10 COMPARISON OF CADMIUM CONCENTRATIONS - Mg/l

(Montana Tech Values v.s. Water Quality Values)

Site No.	Run #1 7/21 Tech° Values	Run #1 7/21 WQB° Values	Run #4 8/9 Tech Values	Run #4 8/9 WQB Values	Run #9 9/18 Tech Values	Run #9 9/18 WQB Values
1	.0064	<.001	<.0005	<.001	<.0005	<.001
2	.0057	.002	.0099	.006	.0037	<.001
3	.0048	<.001	.0063	<.001	.0020	<.001
4	.0078	.001	.0122	.002	.0063	<.001
*						
6	.0108	.007	.0081	.004	.0108	<.001
7	<.0005	<.001	.0013	.001	<.0005	<.001
8	.0169	.010	.0078	.005	.0135	<.001
9	.0042	<.001	.0090	<.001	NT	NT
10	.0132	.014	.0054	.005	.0152	<.001
11	.0027	<.001	.0024	<.001	.0034	<.001
12	.0044	<.001	.0022	<.001	.0312	.047
13	.0019	<.001	<.0005	.001	.0040	<.001
14	.0077	<.001	.0006	.004	.0030	<.001
15	.0074	.006	.0115	.012	.0096	<.001
15A	NT	NT	NT	NT	.0047	<.001
16	.0041	<.001	.0005	.001	NT	NT
16A	NT	NT	NT	NT	.0760	1.01
16B	NT	NT	NT	NT	.0114	<.001
17	.0015	<.001	<.0005	<.001	<.0005	<.001
18	.0017	<.001	.0011	<.001	<.0005	<.001
19	.0027	<.001	.0005	<.001	<.0005	<.001

NT - Sample Not Taken
*Site #5 was dry.
°Montana Tech Values significant to 4 figures; Water Quality Bureau Values significant to 3 figures.

APPENDIX 11 COMPARISON OF COPPER CONCENTRATIONS - Mg/L

(Montana Tech Values v.s. Water Quality Values)

Site No.	Run #1 7/21 Tech Values	Run #1 7/21 WQB Values	Run #4 8/9 Tech Values	Run #4 8/9 WQB Values	Run #9 9/18 Tech Values	Run #9 9/18 WQB Values
1	<.01	<.01	.03	.01	<.01	.01
2	.26	.24	.81	.75	.32	.30
3	.06	.04	.09	.08	.06	.07
4	.17	.20	.45	.50	.22	.26
*						
6	.77	.71	.39	.38	.64	.67
7	<.01	<.01	<.01	<.01	<.01	<.01
8	1.26	1.6	.40	.35	.67	.74
9	<.01	.01	.02	<.01	NT	NT
10	2.1	2.8	.38	.36	.87	.89
11	<.01	.02	.09	.07	.10	.08
12	.05	.08	.07	.07	.12	.14
13	.01	.01	.02	<.01	.01	.01
14	.03	.02	.01	<.01	.06	.03
15	.70	.77	6.2	6.7	.07	.07
15A	NT	NT	NT	NT	.72	1.1
16	.55	.42	.10	.10	NT	NT
16A	NT	NT	NT	NT	190.	177.
16B	NT	NT	NT	NT	.06	.02
17	<.01	<.01	<.01	.01	<.01	<.01
18	<.01	.01	.02	.01	<.01	<.01
19	.03	.02	.01	.04	.02	<.01

NT - Sample Not Taken

*Site #5 was dry.

APPENDIX 12 COMPARISON OF ZINC CONCENTRATIONS - Mg/L

(Montana Tech Values v.s. Water Quality Values)

Site No.	Run #1 7/21 Tech Values	Run #1 7/21 WQB Values	Run #4 8/9 Tech Values	Run #4 8/9 WQB Values	Run #9 9/18 Tech Values	Run #9 9/18 WQB Values
1	.01	.01	.01	.01	.02	.03
2	.59	.56	1.6	1.5	.48	.48
3	.11	.11	.13	.18	.30	.39
4	2.0	2.9	2.4	2.8	1.3	1.4
*						
6	2.5	2.6	1.7	1.5	1.8	1.9
7	<.01	<.01	<.01	<.01	<.01	<.01
8	2.9	2.9	1.1	1.1	1.8	1.9
9	.01	<.01	<.01	<.01	NT	NT
10	3.6	3.6	.95	.94	2.0	2.0
11	<.01	<.01	.02	.01	.03	4.1/
12	.16	.16	.14	.13	1.1	1.1
13	.01	.02	.02	.02	.03	.04
14	.01	.01	.01	.02	.07	.08
15	.12	.14	.30	.31	.07	.08
15A	NT	NT	NT	NT	.20	.22
16	.10	.07	.01	.02	NT	NT
16A	NT	NT	NT	NT	3.4	3.4
16B	NT	NT	NT	NT	.05	.06
17	<.01	<.01	<.01	<.01	<.01	<.01
18	<.01	<.01	<.01	<.01	<.01	<.01
19	.02	.02	.02	.02	.04	.05

NT - Sample Not Taken
*Site #5 was dry
/Very Significant Difference